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Queensland Geological Survey.

PUBLICATION No. 265.

North-Western Queensland.

Geological Notes on the Cloncurry-Camooweal-Burketown-Boulia Area.

WITH

THIRTEEN PLATES OF GEOLOGICAL PLANS, SECTIONS, AND PHOTOS.

By B. DUNSTAN,
CHIEF GOVERNMENT GEOLOGIST.

BRISBANE:
BY AUTHORITY: ANTHONY JAMES CUMMING, GOVERNMENT PRINTER.

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1920.

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NORTH-WESTERN QUEENSLAND.

Geological Notes on the Cloncurry-Camooweal-Burketown-Boulia Area.

Introduction.

That portion of Queensland roughly contained within the area bounded on the north by the Gulf of Carpentaria, on the south by Boulia and the Mulligan River, on the east by the Flinders, Gilliat, and Hamilton Rivers, and on the west by the Northern Territory, is a part of the State not well understood so far as its rock structures and mineral features are concerned, and the district offers a very large and intensely interesting field for geological observations.

Several observers have visited the area and have reported on its geological and mineral features, and the information thus collected has been very useful in helping to solve many of the problems with which we are confronted.

Recently a rapid traverse was made of most of the Cloncurry copper localities and the country about Boulia, Urandangi, Camooweal, and Burketown. The country about Boulia is interesting on account of its artesian and sub-artesian water-bearing beds, while about Urandangi and Camooweal there is an important series of limestone which form an enormous artesian intake. About Burketown and the country to the north-west extensive salt-pans exist in which large deposits of salt are accumulated in the dry seasons of the year.

In returning south from Burketown the Cretaceous marine beds about the Leichhardt River were inspected and a special examination was made of the copper-bearing country of Mount Oxide on one of the upper branches of Gunpowder Creek.

Many years ago Mr. W. O. Hodgkinson took charge of an exploring expedition on the western border of the State, and in his North-west Explorations[1] he describes the character of the

[1] North-west Explorations. By W. O. Hodgkinson, P.P. By Auth. Gov. Printer. Brisbane. 1877. pp. 24.

country along the course of the Georgina River (then called the Herbert River) and the country around the localities now known as Camooweal and Urandangi.

Subsequently the mineral prospects of the Cloncurry field were drawn attention to by Warden Uhr[2] and Dr. Jack,[3] and the latter in his Six Reports on the Geological Features of the Districts about to be traversed by the Transcontinental Railway, written in 1881, gives a description of some of the mineral localities. References are made therein to many gold and copper mining operations in progress at that time and also to the large outcrop of ironstone near Cloncurry called Mount Leviathan or Black Mountain.

In 1895 the late Mr. Rands examined portions of the Cloncurry Field and reported on the general prospects of gold and copper mining, and specially on the Leichhardt Goldfield just then opened.[4]

Dr. Jack in 1895 read a paper before the Queensland Royal Society on the Georgina Basin, and gave some notes on artesian water supplies.[5] The notes specially bearing on the character of the Georgina country, and to which reference will be made, are those in which he states that the earlier explorers of this part of Queensland considered the beds were Cretaceous (Rolling Downs) but that he thought they were of metamorphic origin.

"Geological Observations in North-Western Queensland" is the title of a report furnished by Mr. Cameron in the Annual Progress Report of the Mines Department for 1900, in which he describes the western boundary of the artesian water basin, the characteristics of the older slate, quartzites, &c., the (?) Devonian sandstones and limestones, and the Post Tertiary limestones of

---

[2] Annual Report, Department of Mines, for 1883. Cloncurry Mining Districts. By Reginald C. H. Uhr, Commissioner, pp. 214 and 215 (1884).

[3] Bulletin No. 10. Six Reports on the Geological Features of part of the District to be traversed by the proposed Transcontinental Railway, 1881-2, with two maps. By Robert L. Jack, Government Geologist, G.S.Q. Pub. No. 136 (Reprint of No. 10) pp. 46. By Auth. Brisbane, 1898.

[4] Leichhardt Gold Field and other Mining Centres in the Cloncurry District. By William H. Rands, Assistant Government Geologist, foolscap C.A. paper. G.S.Q. Pub. No. 104, pp. 7. By Auth. Brisbane, 1895.

[5] Stratigraphical Notes on the Georgina Basin, with Reference to the Question of Artesian Water. By R. L. J. Proc. Roy. Soc. Q'land, vol. xi., pt. 2, pp. 71-74. 1896.

the Barkly Tableland.[6] A vertical section is also included showing the artesian water-bearing strata and associated formations between Hughenden and Cloncurry.

In 1900 Mr. Cameron wrote a report on "Recent Developments in the Copper Mining Industry in the Cloncurry District," and in addition to describing the lodes in the numerous mining centres offers some remarks about the general geological features of the copper-bearing rocks. Accompanying his report is a map of the district giving the geological boundaries of the formations examined.[7]

Mr. Cameron also reported on the silver-lead mines of Lawn Hills, in the Burketown Mineral Field, and in his report refers to the mines and lodes, and gives some geological notes on the occurrence of the minerals.[8]

The Report of the Royal Commission on the Federal Iron Bonus Bill, issued in 1903, contains the evidence given by officers of the Geological Staff and others on the prospects of obtaining iron ore in the Cloncurry District and attention is specially drawn to the iron ore deposits of Mount Leviathan. A reprint of the evidence is given in Records No. 1.[9]

Mr. Ball in 1908 visited nearly all the copper mines on the Cloncurry Field, and in Part 1 of his report he gives physiographical, geological, mineral, and bibliographical notes, Part 2 being devoted exclusively to descriptions of the numerous mineral holdings.[9A]

The Queensland Mineral Index, published in 1913, contains a long list of the minerals reported to occur in the Cloncurry Fields, also a Proclamation of the Field Boundaries, the principal mining centres, notes on gold and copper discoveries, and mineral statistics.[10]

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[6] Annual Progress Report of the Geological Survey for the year 1900. By Auth. Brisbane. G.S.Q. Pub. No. 159, pp. 10-15 (1901).

[7] Recent Developments in the Copper Mining Industry in the Cloncurry District. With map and four plates. By Walter E. Cameron, B.A., Assistant Government Geologist. Foolscap C.A. Paper, pp. 10. By Auth. Brisbane, 1900. G.S.Q. Pub. No. 153, pp. 10

[8] Lawn Hills Silver-Lead Company, Mended Hills, North Queensland. By W. E. C. 1900. Bris. By Auth. G.S.Q. Publication No. 138, pp. 3.

[9] Records No. 1. By B. Dunstan, Acting Government Geologist, 8vo. By Auth. Brisbane, 1904. G.S.Q. Pub. No. 190, pp. 12-25.

[9A] Cloncurry Copper Mining Districts (Parts 1 and 2). With 1 map, 1 plate, 76 plans, and 32 figures. By Lionel C. Ball, B.E., Asst. Government Geologist, 8vo. By Auth. Brisbane, 1908. G.S.Q. Pub. No. 215.

[10] Queensland Mineral Index and Guide. With numerous Diagrams and Tables, and an Atlas of 36 maps. By B. Dunstan, Government Geologist, 8vo. By Auth. Brisbane, 1913. G.S.Q. Pub. No. 214; pp. 1014.

Annual Progress Reports of the Wardens and Inspectors of Mines are published in the Annual Report of the Mines Department and Monthly Reports in the columns of the Queensland Government Mining Journal. The information contained therein concerns individual mines and companies and forms a useful record from year to year of mining operations from a general and semi-technical point of view. A special Warden's report by Mr. Cherry was published in 1905, in which a description is given of a visit to the copper mines on the Corella River, westerly from Cloncurry.[11]

Dr. Danes, of Austria, made a physiographical examination of North-Western Queensland in 1910, and contributed to the Queensland Royal Society in that year a paper on the Physiography of Some Limestone Areas in Queensland."[12] He calls attention to the limestones of the Barkly Tableland and to the subterranean supplies of water they contain.

Mr. Ball in 1911 examined in detail the mines of the Burketown Mineral Field and furnished a considerable amount of data concerning the silver-lead mines of Lawn Hills.[13]

A report by Dr. Woolnough on the Northern Territory, issued as a Bulletin by the Commonwealth Government in 1912, contains geological references to that part of North-Western Queensland adjacent to the Northern Territory. The stratigraphical and mineral features of the rock systems are described and notes are included on the Barkly Tableland limestones and the artesian water-bearing beds.[14]

Mr. George Phillips in 1909 furnished the Railway Department with a "Report on the Advisability of Constructing Railways and Ports connected therewith in the Gulf of

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[11] Copper Mining on the Corella River. By Fred. J. Cherry, Warden. Queensland Government Mining Journal, vol. 6, p. 139. 1905.

[12] Proceedings of the Royal Society of Queensland, vol. XXIII., Part 1. Physiography of some Limestone Areas in Queensland. By Dr. J. V. Danes (Prague Czech University), 1911.

[13] The Burketown Mineral Field (Silver-Lead and Zinc Mines), with 3 maps, 23 plates, and 40 plans. By L.C.B. 1911. Brisb. By Auth. G.S.Q. Pub. No. 232; pp. 57.

[14] Bulletin of the Northern Territory. No. 4 Report on the Geology of the Northern Territory. By W. G. Woolnough, D.Sc., F.G.S. Published by the Department of External Affairs, Melbourne. 1912.

Carpentaria.''[15] Part 2 deals with the mineral areas about Cloncurry, Part 3 with the flows of the rivers, and Part 5 with the Gulf ports. Accompanying the report are several plans, charts, and barometric sections.

''Resources of the Gregory for Settlement and Population'' is the title of a pamphlet published by the ''Cloncurry Advocate'' for the Burketown Shire Council.[16] It includes amongst other items some extracts from the reports by Captain G. W. Williams and Captain G. A. Richards on the Mount Oxide Mine.

Dr. Jensen furnished a geological report in 1914 on his work in the Northern Territory, which was issued as Bulletin No. 10 by the Commonwealth Government. It contains many references to the Geology of North-Western Queensland, more particularly about the area between Camooweal and Cloncurry.[17]

In 1917 a Royal Commission inspected the route of a proposed railway from Oona Station to Mount Oxide and expressed the opinion that from a mining standpoint the reserves of ore in sight did not warrant a line being constructed.[18]

In the ''Daily Mail,'' Brisbane, a series of articles were contributed in (?)1918 by Mr. John H. C. Sleeman on ''A Neglected Province, North-West Queensland.'' The articles deal principally with the copper resources of the Cloncurry area, and several of the most important mines are described.

Mr. S. Harris, metallurgist at Mount Cuthbert, in 1918 and 1919 contributed three articles to the ''Chemical, Engineering, and Mining Review'' drawing attention to the ''Resources of the Cloncurry Copper Field''[19] in which he reviews the prospects of

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[15] Report by Mr. George Phillips, C.E., upon the Advisability of Constructing Railways and Ports connected therewith on the Gulf of Carpentaria. F'cap. C.A. Paper. By Auth. Brisbane, 1909.

[16] Resources of the Gregory for Settlement and Population. Issued by authority of Burketown Shire Council and compiled by proprietor of ''The Cloncurry Advocate.'' 1917 ?

[17] Bulletin of the Northern Territory No. 10. Geological Report on the Darwin Mining District, Macarthur River District; The Barkly Tableland. By H. I. Jensen, D.Sc., Director of Mines. Published by the Department of External Affairs, Melbourne. 1914.

[18] Report of the Royal Commission appointed to inquire into and report upon a Proposed Railway from Oona (on the Cloncurry-Mount Cuthbert line) to Mount Oxide, a distance of 85 miles. F'eap. C.A. Paper 123. By Auth. Brisbane, 1916.

[19] Resources of the Cloncurry Copper Field, N.Q. By S. Harris, Manager, Mt. Cuthbert No Liability. Reprinted from Chemical Engineering and Mining Review, Nov., Dec., 1918, Jan., 1919.

the field, describes some of the mines, and gives his opinion on the problems associated with the future treatment of the low-grade copper ores.

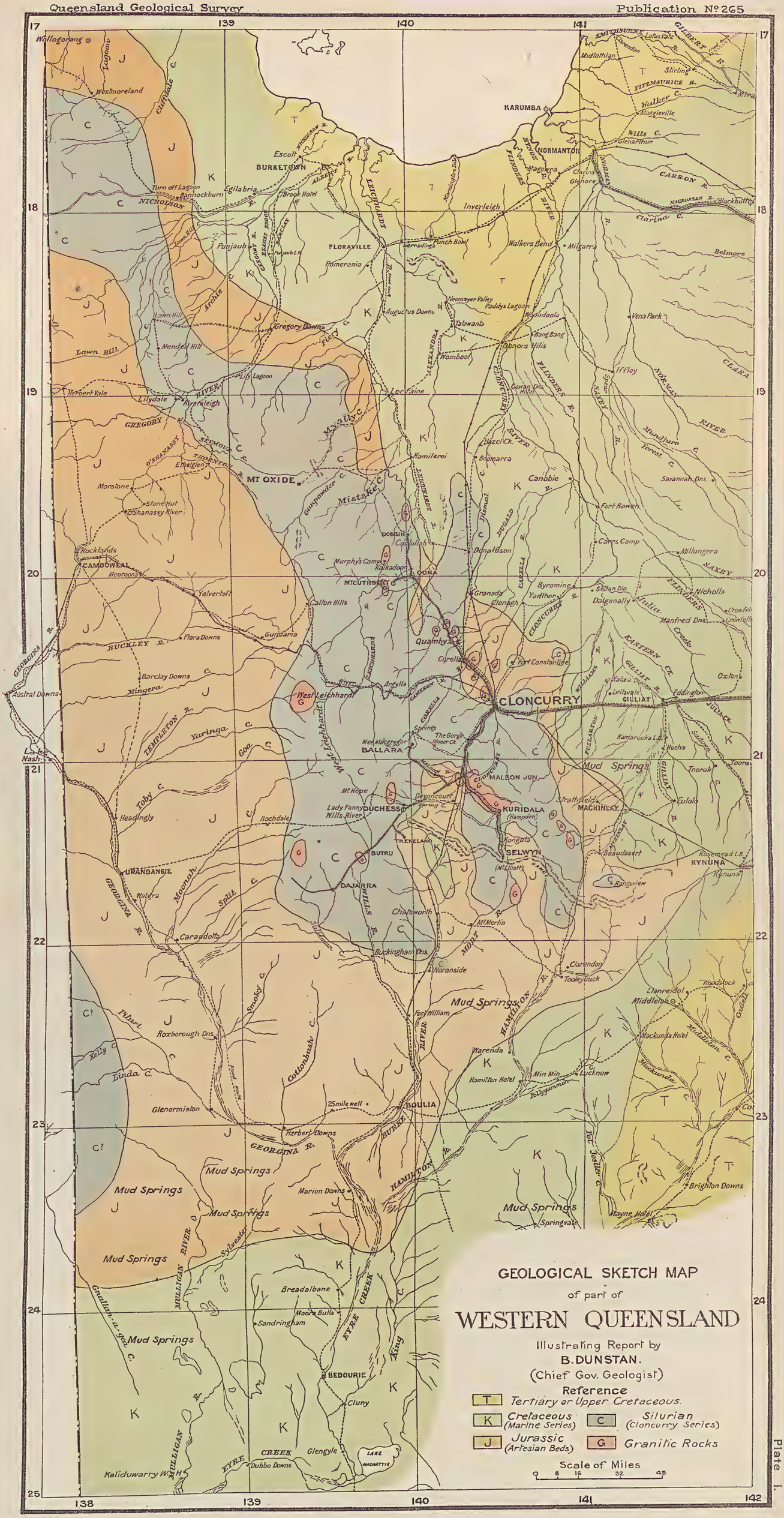
During the present year a Royal Commission reported on the Construction of Railways between Cloncurry and the Gulf of Carpentaria[20] and the evidence published contains many opinions on the mineral and other resources of this part of the State.

The last edition of the Geological Map of Queensland, issued in 1907 on a scale of 40 miles to 1 inch, shows that a large area of country to the west and south-west of Cloncurry has been assigned to the Silurian System and that it forms portion of the same series as the Cloncurry mineral-bearing country, while the Barkly Tableland is mapped as partly Devonian and partly Tertiary. The previous edition of the Geological Map, on a scale of 16 miles to 1 inch, issued in 1899, shows similar features except that all the Barkly Tableland is placed as Devonian. In the old edition of the larger scale map issued in 1892 the country south and south-west of Cloncurry is shown to be portion of the artesian intake area, and the recently mapped boundary between this formation and the Cloncurry mineral area agrees so closely with this old work that no hesitation is felt in adopting the same lines for the map (Plate 1) issued with this report, and in discarding those shown in the last two editions of the State Geological Map.

Topographical Note.

Around Cloncurry to the south-east, south, west, and north-west within a radius of 70 or 80 miles there are very pronounced topographical features in the way of long, narrow and precipitous ranges. To the south and south-east these ranges have a northerly trend and about Cloncurry the same direction is observed, but further north the trend is towards the north-west, with variations between westerly and northerly about Mount Oxide. Beyond this point the ranges have a north-westerly direction, which they are said to preserve in passing over into the Northern Territory to the west of Burketown. In this long belt of country the long, narrow ridges are separated by wide valleys or by low undulating hills, and sometimes the ridges are without a passable gap for twenty or more miles, while to traverse the country in some parts it is necessary to make detours a long way off the direction in which it is desired to go.

[20] The Royal Commission appointed to Investigate and Report upon Certain Proposals for the Construction of Railways in the Gulf districts to connect with the Back Country. Brisb. By Auth., Gov. Printer, 1919. C.A. Paper; pp. 112.


GEOLOGICAL SKETCH MAP
of part of
WESTERN QUEENSLAND
Illustrating Report by
B. DUNSTAN.
(Chief Gov. Geologist)
Reference
T Tertiary or Upper Cretaceous.
K Cretaceous (Marine Series)
C Silurian (Cloncurry Series)
J Jurassic (Artesian Beds)
G Granitic Rocks
Scale of Miles
0 8 16 32 48
CLONCURRY
MT OXIDE
BURKETOWN
NORMANTON
KARUMBA
FLORAVILLE
CAMOOWEAL
DUCHESS
BALLARA
MALBON JUN
KURIDALA (Hampden)
MACKINLAY
SELWYN (Mt Elliott)
KYNUNA
BUTRU
DAJARRA
URANDANGIE
BOULIA
BEDOURIE
MCCUTHBERT
DOBLIN
DONA
Mud Springs
Gregory R.
Nicholson R.
Leichhardt R.
Flinders R.
Georgina R.
Hamilton R.
Mulligan R.
Eyre Creek
Burke R.
Wills R.
Fitzmaurice R.
Gilbert R.
Carron R.
Macrossan R.
Clarina C.
Belmore
Inverleigh
Punjaub
Escott
Brook Hotel
Egilabria
Turn off Lagoon
Bannockburn
Westmoreland
Lawn Hill
Mended Hill
Lily Lagoon
Herbert Vale
Lilydale
Riverleigh
Gregory Downs
Augustus Downs
Talawanta
Wombool
Paddys Lagoon
Neumayer Valley
Walkers Bend
Milkarr
Punch Bowl
Bernadino
Pomerania
Lochaine
Kamileroi
Bloomarra
Hazel Ck.
Canobie
Fort Bonah
Carns Camp
Millungera
Savannah Dns.
Vena Park
Iffley
Bang Bang
Donors Hills
Gowan Dns. Hotel
Rocklands
Woorooma
Yelvertoft
Flora Downs
Gundaria
Calton Hills
Murphy's Camel
Kalkadoon
Granada
Clonagh
Byroming
Yadthore
Skelan Dip
Dalgonally
Nicholls
Manfred Dns.
Crowfield
Quamby
Corella
Fort Constantine
Argylla
West Leichhardt
Mingera
Barclay Downs
Austral Downs
Lake Nash
Yaringa
Coa
Toby
Headingly
Rochdale
Lady Fanny
Wills River
Devoncourt Spring
Mt Hope
Mt Merlin
Chelsworth
Buckingham Dns.
Woranside
Clarendon
Tooley Back
Walgra
Caraudolla
Roxborough Dns.
Glenormiston
Herbert Downs
Marion Downs
Sandringham
Moora Bulla
Breadalbane
Cluny
Glengyle
Dubbo Downs
Kaliduwarry Well
Lake Macmattie
Fort William
Warenda
Hamilton Hotel
Min Min
Lucknow
Mackunda Hotel
Middleton
Llanrelloi
Woodstock
Brighton Downs
Mayne Hotel
Springvale
Rangeview
Beaudesert
Rosemead L.B.
Kanjarooka L.B.
Huelva
Toorak
Eulolo
Strathfield
Leilvale
Oxton
Eddington
Sedan
Toora
Cronfield
Crowfell
Millungera
Saxby
Judack
Gilliat
Eastern Ck.
Creek
Cloncurry R.
Williams R.
Fullarton R.
Corella R.
Canobie R.
Julia Ck.
Leichhardt R.
Mistake Ck.
Gunpowder Ck.
Myally Ck.
Seymour R.
Thornton R.
O'Shanassy R.
Archie Ck.
Lawn Hill
Fiery Ck.
Alexandra
Elizabeth
Gregory R.
Buckley R.
Templeton R.
Georgina R.
Moonah Ck.
Split Ck.
Toby Ck.
Yaringa Ck.
Pibarl
Kelly Ck.
Linda Ck.
Smoky Ck.
Cottonbush Ck.
Sutherland
Mort
Hamilton R.
Middleton Ck.
Mackunda
Cudell
Ranken R.
Ranken
Davenport
Sylvester
Mulligan R.
Eyre Creek
Kiny
Breadalbane
Sandringham
Moora Bulla
Glengyle
Dubbo Downs
Kaliduwarry Well
Lake Macmattie
Cluny
Bedourie
Mud Springs
Mud Springs
Mud Springs

Geological Features.

General.

The geological features of North-Western Queensland were practically unknown until Dr. Jack made an examination and issued his Six Reports on the country proposed to be traversed by the Transcontinental railway line. He expressed the opinion that the Cloncurry Series of slates and schists formed a long north-west and south-east belt of mineral-bearing country, with one large area of artesian-water bearing beds to the north-east and another one to the south-west. Modifications of these boundaries were made subsequently as a result of various observations, and are shown on his 1899 edition of the geological map of the State, a reference to which is made on a previous page. He included in the Silurian the large area between Cloncurry, Boulia, and the border of the Northern Territory. In his paper on the Georgina Basin[21] he states that earlier explorers considered this part of Queensland to be "Rolling Downs," *i.e.*, Cretaceous, and placed it as such on his 1892 edition of the Geological Map of Queensland. Subsequently, on the results of boring operations, he considered the mapping wrong, and in the next edition of the map in 1899 the area appeared as Silurian. All our recent work, as previously stated, shows that this alteration was not justified and that the observations of the earlier explorers were quite correct.

The recent examination entailed an inspection of the country lying between Cloncurry, Boulia, Urandangi, Camooweal, Gregory Downs, and Burketown, the rivers crossed and examined during the tour comprising the Cloncurry, Burke, Wills, Georgina, Seymour, Thornton, Gregory, Nicholson, and Leichhardt. A conception was formed therefore of the whole of the geological features on a broad scale and, in consequence, with less liability to error than if the work were undertaken by different observers working over limited areas.

Silurian (Mineral Bearing).

The examination shows that the country about Selwyn, Duchess, Cloncurry, Argylla, and Dobbin, and between the latter station and Mount Oxide, and also the country extending to Lawn Hills and to the Northern Territory beyond Wollogorang,

[21] *Loc. cit.*, p. 73.

in lat. 17°, forms an immense mineral-bearing belt of slates, schists, quartzites, limestones, and dolomites, with occasional granites and other igneous rock masses.

The slates and schists are generally argillaceous, calcareous, and ferruginous, and contain graphite, anthracite, mica, hornblende and various ferro-magnesian silicates. The quartzites form prominent ranges extending for miles, and sometimes very massive beds of this rock are to be seen with and without slate interlaminations. The limestones and dolomites alternate with the slates and schists and are nearly always crystalline. They are occasionally massive and free from impurities but are usually finely interbedded with other rocks and more or less siliceous.

All the sedimentary rocks are severely contorted, the axes of the folds of which are generally in a north and south direction, with very little subsequent movement having taken place to disturb the uniformity of their folds. The quartzites withstand weathering much more effectively than the slate, schists, and limestones, and consequently the latter occupy the flat or undulating country lying between the quartzite ranges.

The palæontological evidence bearing on the age of these altered sediments is very meagre and leaves much to be done before anything definite can be said about the geological horizon of the Cloncurry series. Perhaps the most serious objection to classifying the beds as Silurian is the fact that carbonaceous shales are interbedded with other rocks at several localities in the mineral belt. At Mount Oxide there are carbonaceous shales about 60 ft. in thickness containing 12 per cent. of fixed carbon, while at Lilydale, further north-west on the Gregory River, similar shales are to be observed containing 5 per cent. of hydrocarbons and 2·2 per cent. of fixed carbon.[22] At Mended Hill and Tunnel Hill, to the north of Lilydale other occurrences of these shales have been recorded and some of the carbon in the rocks at the last-named hill has been isolated and found to contain 85 per cent. of fixed carbon, 3·1 per cent. of hydrocarbons, and 9 per cent. of ash.[23]

Another occurrence is at Hampden, where a prospector found 22 feet of graphite and graphitic shale in association with a copper lode.[24] The presence of the carbon in the shales causes

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[22] Dr. Jack's Six Reports, 1898.

[23] Mr. Ball's Burketown Mineral Field Report, 1900.

[24] Graphite in Queensland. By B. Dunstan. Brisb. By Auth. 1906. G.S.Q. Pub. 203, pp. 11.

some doubts to be raised both regarding the age of the beds and whether the carbon is of sedimentary origin, but, nevertheless, such fossils, &c., as have been found are classed as Silurian, and without further information nothing can be done to allocate the Series to another System.

The fossils include *Actinoceras sp. ind., Orthoceras sp. ind., Orthoceratites sp. ind.*, and some bivalves from Cairns Range, situated at the head of the Mulligan River and close to the border of the Northern Territory, and *Stromatopora sp.* from Pumpkin Gully, 12 miles east of Cloncurry.

The granites appear to be an extreme stage of metamorphism of the schists, with which they invariably conform in their trend, and in no case have they been recorded as intruding other rocks. Often they are very coarsely crystalline, their usual texture, however, being medium or fine-grained. Variations of the granite as a type are quite common, hornblende being a conspicuous mineral, and biotite comparatively rare, while gradations into schists without mica are often to be seen.

Diorite, gabbro, and hornblende rock were also observed, but their relation to the sedimentaries and to the other igneous rocks could not be ascertained. They appear to have no bearing on the mineral deposits nor to be connected with them in any way, but more information is desired before a decided opinion can be expressed.

These geological features apply to the whole of the Cloncurry Series, extending from one end of the belt to the other, the length of which is about 400 miles, the width being about 40 miles with a variation between 25 and 100 miles.

The minerals occurring in this belt appear to be extensively distributed, more particularly copper, deposits of which in one form or another are recorded from a large number of localities. Near Cloncurry several large copper lodes have been opened up and worked to a limited extent. Their possibilities have not been defined however by any means, and they might produce large quantities of metal in the future.

Far beyond Cloncurry there are also large deposits of copper which are frequently high in values, but which cannot be worked on account of their inaccessibility and want of railway communication. These deposits vary considerably in richness and may be composed exclusively of low-grade ore too poor to pay without very cheap transit arrangements or some very economical

methods of treatment, or they may consist of small bodies of very rich ore associated with large quantities of low-grade material.

Small copper lodes occur in great numbers, some being narrow but otherwise having favourable features, while others are merely superficial deposits and have neither length or depth, and leaving no indication to show where to expect their continuation.

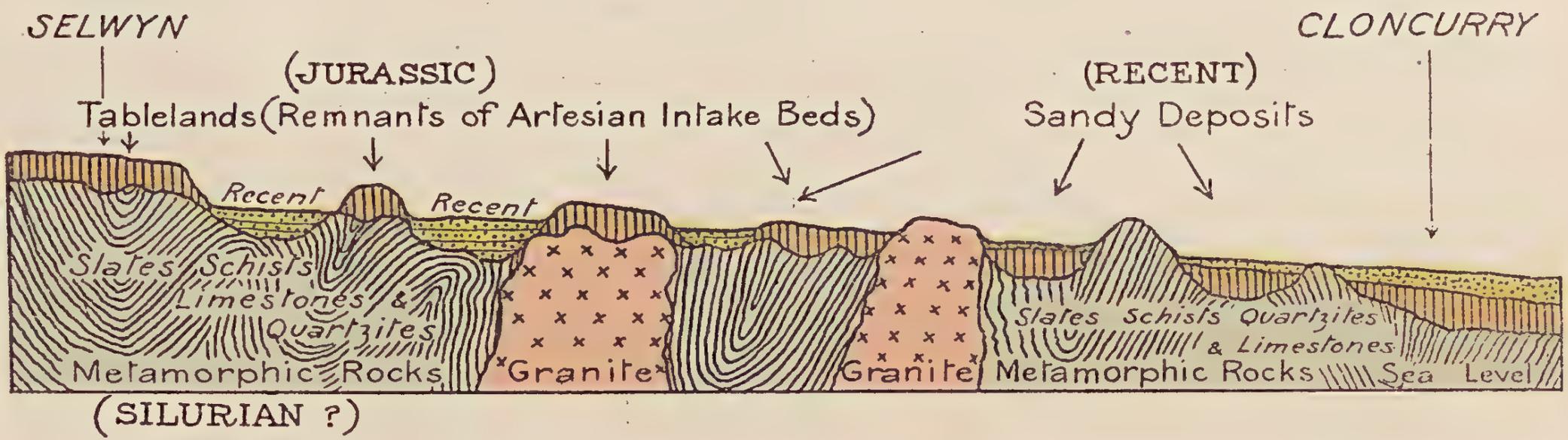
Other than copper the Cloncurry mineral belt has not yielded, up to the present, any minerals of value except gold, and the value of that has not been very great. The district has prospects, however, in the way of iron ores, mica, magnesite, dolomite, limestone, marble, roofing slate, ornamental building stone, and pigments. There are many thousands of square miles of country which have not been prospected scientifically, and in many parts not even casually, but which contain innumerable copper lodes, large and small, and probably also deposits whose value will remain insignificant until more facilities exist for their transportation.

The Geological Sketch Map of North-Western Queensland (Plate 1) attached shows the boundaries of the Series and the granite areas so far observed. Plate 2, illustrating a geological diagrammatic section between Cloncurry and Selwyn (Mount Elliott), shows the Cloncurry Series in relation to the granite masses and more recent deposits covering it. Plate 3 represents a diagrammatic section between Cloncurry and Carlton Hills to the W.N.W., the latter being the position where the Cloncurry Series are submerged beneath the limestones of the Jurassic artesian-water series. Plate 4 is a diagrammatic section across Boulia, Urandangie, Camooweal, and Burketown, and shows the exposure of the Cloncurry Series on the Gregory River, where an artesian leakage takes place. Plate 5 represents a section across the Mulligan and Georgina Rivers to the Duchess copper area, the latter being the divide separating two sub-artesian areas.

Jurassic (Artesian Water) Beds.

To the north-east and south-west of the Cloncurry mineral belt, and resting on it, are a series of regularly bedded rocks forming the outcrops of the Jurassic or Artesian Series, above which are the conformable Cretaceous Marine Beds, and also in scattered places an irregular limestone formation of probably Tertiary or Post Tertiary Age.

SELWYN – CLONCURRY SECTION
(DIAGRAMMATIC)



S ——— Section About 60 Miles in Length ——— N

W.H.R. Del.

Plate 2

The beds on the north-east side of the mineral belt of country are mostly made up of sandy and clayey rocks, with limestones at the northerly end. They are to be observed in the narrow areas of sub-artesian country about the Gregory River near Gregory Downs, and also near the Leichhardt River at Lorraine, Kamileroi, and Cooloobah, while further south-east they occur about Granada, Fort Constantine, Oorinda, Strathfield, and Beaudesert. At Cabbage Tree Creek, a branch of the Leichhardt River, coal has been found in this series, reference to which is made under the heading "Coal Deposits."

On the south-western side of the mineral belt the beds are made up, almost exclusively, of slightly sandy limestones and dolomites, which form very few outcrops, are almost invariably bedded horizontally, and cover an immense area of country. They occur some miles to the west of Lawn Hills and Riversleigh Stations and sections are very conspicuously shown in the rugged country about the O'Shannasy, Seymour, and Thornton Rivers. Further south they are to be observed at Herbert Vale, Camooweal, Barkly Downs, Urandangi, and Carandotta, and extend westerly and south-westerly to and beyond the Northern Territory border. At Camooweal the limestones are in part made up of angular fragments, and portions of the brecciated rock have been changed to quartzite ("billy"). Some of the unaltered limestones also contain quartzite derived, no doubt, from formations below the surface and probably covered by limestones, and amongst fragments of this quartzite, weathered out of the limestone are the "ribbon-stones" used locally for jewellery purposes. Southerly from Cloncurry at Devoncourt, Selwyn (Mount Elliott), Chatsworth, Mount Merlin, Noranside, and Boulia similar limestones sometimes occur with a lateritic overburden, both of which are submerged below the Cretaceous Marine Beds of the Hamilton River. These localities and geological features are shown on Plate 1 (Map) and other plates illustrating geological sections, all indicating the presence of a great expanse of artesian intake country containing sub-artesian supplies of water.

The lateritic overburden referred to is well-developed about Soldiers' Cap and Selwyn, where isolated tablelands forming conspicuous features in the landscape scenery are made up of this material. These rocks evidently were in part sub-aerially formed and gradually merged into water-formed beds further east, while at the same time fresh water limestones were being accumulated on the western side of the Cloncurry Mineral Belt.

The tableland country at Selwyn is shown on Plate 2, the section also illustrating its gradual envelopment by more recent deposits as it dips below the surface to the north about Cloncurry.

The limestones appear to be horizontally bedded and no perceptible change of level can be observed in the field, although there is an actual inclination to the south and south-west. The sub-artesian water in the bores at Camooweal rises a few feet above the position at which it is met with in boring, while further south the water rises nearer and nearer to the surface, until at Sandringham to the south-west of Boulia and near Lake Phillipi the water actually overflows. The section between Camooweal and Sandringham is a fine example of the theory that artesian water is derived from meteoric sources.

To the east of the mineral belt similar conditions prevail although the gradation from sub-artesian to artesian conditions is much more rapid and the area of sub-artesian country in consequence is very much more limited. The boundary between the artesian and sub-artesian areas is given approximately on Plate 1, but the decided decrease in the flow of water from the bores, which has been proved to be fairly constant throughout the artesian system, and the consequent lowering of the water levels will gradually enlarge the sub-artesian area and decrease the artesian one, so that from time to time a change in the position of this boundary will be necessary.

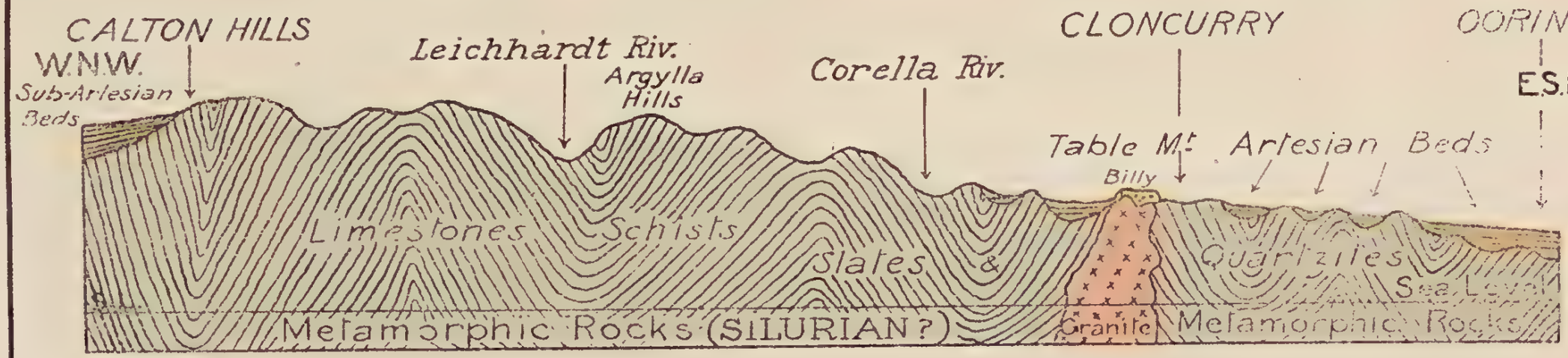
The thickness of the strata comprising the artesian zone is not easy to determine on account of the irregularity of many of the boring records. There is also the difficulty when boring in deciding where the artesian zone begins and where the drills pass below it. Nevertheless, the average thickness may be taken to be 2,000 feet, with variations showing a greater depth occasionally and a shallower depth frequently.

The opinion has been expressed that the artesian beds thin out as the edge of the basin is approached, a result either of recent denudation or of being so formed originally, but so far as the western portion of the State is concerned the Cloncurry mineral belt, with the later-formed sediments, is a comparatively recent elevated area, and the thinning out must be quite local and without any necessary connection with the limits of the basin. The artesian or sub-artesian areas east and west of the Cloncurry Series no doubt were connected at one time and formed parts of one large area, with the older rocks elevated to form islands in the midst of Jurassic swamps and lagoons, followed by total submergence in a Cretaceous sea.

CALTON HILLS-CLONCURRY-OORINDI SECTION

(DIAGRAMMATIC)

Shewing the Mineral Belt of Country partly covered by Artesian Beds



Section About 120 Miles in Length

W.H.R. Del.

Plate 3

OF VICT

Noticeable features connected with the sub-artesian and artesian areas are (1) the abnormal flow of water from the sub-artesian limestones about the heads of the Gregory River, (2) the absorption of surface water by the limestones throughout the Urandangi-Camooweal districts, (3) the presence of seams of coal east of the Mulligan River, (4) the occurrence of mud springs about the Hamilton River and (5) the formation of superficial salt deposits within the Mulligan River basin.

Concerning the first feature it is well known that the Gregory River near the junction of the O'Shannasy River is a strongly flowing stream throughout the year, and the O'Shannasy itself is also considered to be perennial. Both the Gregory and O'Shannasy rivers head in artesian intake areas and the springs at their source may be considered artesian leakages. These springs are not due to strata dislocations but to the removal by denudation of the artesian beds which once covered the older Cloncurry Series in this part of the country and which at one time no doubt connected the basins on the eastern and western sides. To the east of Constance Range, where Lawn Hills Creek and other streams head, several springs occur and probably originate in the same way.

The flows of the Gregory and O'Shannasy Rivers near their junction about Riversleigh amounts to 83,000,000 and 23,600,000 gallons per day, respectively,[25] and this must actually be the result of artesian leakage, and as such must have a marked effect on the hydrostatic level of the artesian water in the artesian basin in the Burketown District. The work of the officers of the Water Supply Department has shown that the height above sea-level of the flows of the bore waters gradually become lower as the Gulf of Carpentaria is approached from the south-east, and no doubt this lowering of the isopotentials is directly due to the absence of supply on the north-western end of the basin, a result of the leakage at the springs. If the large amount of water now flowing to waste in the Gregory and O'Shannasy rivers were conserved in the artesian beds the isopotential lines would probably be very different to what they are now shown to be. Nature has in this instance caused an enormous waste of water which could have been put to much better use had it been allowed to escape only through the medium of artesian bores. On Plate 4 is shown a geological section between Boulia and Burketown, which illustrates the leakage on the O'Shannasy River.

The absorption of surface water by the limestones of the Georgina basin is an extraordinary occurrence, although it is

[25] Water Supply Department's recent figures.

said that in the Northern Territory other large areas of limestone exist in which the same natural phenomenon is to be observed. About Camooweal there are hundreds of deep quarry-like excavations which have been formed in the horizontally-bedded limestones and in which rain water rapidly disappears after storms. The limestones have been leached away and the caverns below are artesian intake reservoirs. In some cases, as at New Carlo Station, on the Mulligan waters westerly from Glenormiston, underground streams have been met with which have a distinct flow, and the waters of the Georgina River, except in flood time it is said, are totally absorbed by the cavernous limestones which cross its bed.

The occurrences of mud springs about the Hamilton River and the salt deposits of the Mulligan River will be referred to further on.

In the artesian bores sunk about Sandringham, to the east of the Mulligan River, several occurrences of a seam of brown coal several feet thick have been recorded, the coal being of poor quality and containing much iron pyrites. This horizon is below the Cretaceous marine beds and quite distinct from that of the coal found in bores in the Winton Series close to the surface, which is probably Upper Cretaceous and which occurs in strata resting on the marine beds.

The deep Patchawarra bore, situated north of Cooper's Creek in South Australia and not far from the Queensland border, failed to find artesian water although sunk to 5,458 feet, but passed through seams of lignite above marine beds. As the Sandringham coal occurrences are in the water-bearing Jurassic strata probably it has no relation to the Patchawarra coal, the latter being a deep extension of the Cretaceous(?) coalbeds occurring in the Winton Series.

The only fossil found in the Jurassic rocks in Western Queensland is a specimen of tree fern the horizon of which is probably in sandy beds between the water-bearing limestones and the marine beds above. The specimen is a portion of a tree-fern trunk about 8 inches in diameter and about a foot long, and was found at Curridgee Waterhole on the Burke River, 16 miles south-west of Boulia.

Lower Cretaceous Marine Series.

The Cretaceous marine beds resting conformably on the Jurassic artesian beds occur as outcrops in several localities on the north-eastern side of the Cloncurry mineral belt and extend

north-westerly and south-easterly without an apparent break for a distance of about 300 miles. In the south-east of the mineral belt they are also present, and trend along the course of the Hamilton River to the junction of the Georgina River and thence westerly towards and probably beyond the border of the Northern Territory.

Localities where definite palæontological evidence has been collected are very numerous and include—starting from the most northerly occurrence—Kamileroi and Cooloolah on the Leichhardt River, Granada on the Dugald River, the main road crossing Williams River to the east of Cloncurry, Holy Joe Creek, a branch of the Gilliat River, Beaudesert, Toolebuc, Polygammon Creek, Warenda, Mount Datson (the four latter on the Hamilton River), Davencourt to the west of Selwyn, and a spot in lat. 24° and long. 138° 30′ to the west of the Mulligan River. Cretaceous marine fossils were found to the west of the Mulligan River by Mr. McIntyre, a well borer, and their presence here shows that the marine beds probably pass across the Northern Territory border in lat. 24° to the south of the Silurian rocks of Cairns Range and from there trend westerly. The occurrence of Cretaceous marine strata so far to the west has some significance in showing that as artesian water very probably exists below the actual outcrops of such fossiliferous beds and also exists in areas towards which these beds are dipping their discovery to the west or north-west of Cairns Range, if proved, would probably lead to important results in enabling sites to be fixed for artesian bores.

The Cretaceous Marine Series easterly from Cloncurry have been abnormally developed and a vast area of these rocks, extending easterly 200 miles to Hughenden from the Williams River, and also as far south as Winton, must have a thickness varying up to 4,500 feet. About Winton and further west at Collingwood, the maximum thickness of 4,500 feet is reached, this great depth of strata being due to the gradual formation of a long, deep, narrow depression in the Jurassic beds at the same time the Cretaceous marine sediments slowly accumulated above them. Further south this thickness of marine strata rapidly diminishes, the variation generally being between 2,000 and 2,500 feet, with one area at Tambo showing a thickness of about 3,500 feet.

Consideration was given to the possibility of two marine belts existing one above the other with a freshwater series between, and with that view in mind an attempt was made to establish a deep series with outcrop to the extreme north, east

and west of the artesian basin, and a shallow one on top of this around about Winton, but it was found that the marine beds apparently continued without a break between Hughenden and Winton, so that the idea of establishing upper and lower marine zones had to be abandoned.

In plotting the data from the artesian boring records on to our geological maps the marine beds were assumed to be 2,000 feet thick and that any strata above this were considered to be a freshwater series, that is to say, if a bore reached the water zone at 3,000 feet there would be 2,000 feet of marine beds above this with 1,000 feet of freshwater beds between the top of the marine beds and the surface. With the exception of the Winton-Collingwood area and another one around Tambo it was found in plotting the work that the outcrops of the marine strata occurred on the side of this line where the bores were shallow and the freshwater series on the side where the bores were deep. On this basis we have divided the outcrops of the Cretaceous Marine Series from those of the Cretaceous Freshwater (Winton) Series, and the boundaries thus designed will represent the assumed junction of the outcrops of the two Series. There are of course some objections to adopting this method of geological mapping, but it has its advantages in the readiness with which the approximate position of the artesian intake outcrop can be found in the areas in which shallow and deep artesian beds exist or may be expected to occur.

The Cretaceous marine fossils found in the North-Western and Western Queensland include the following:—

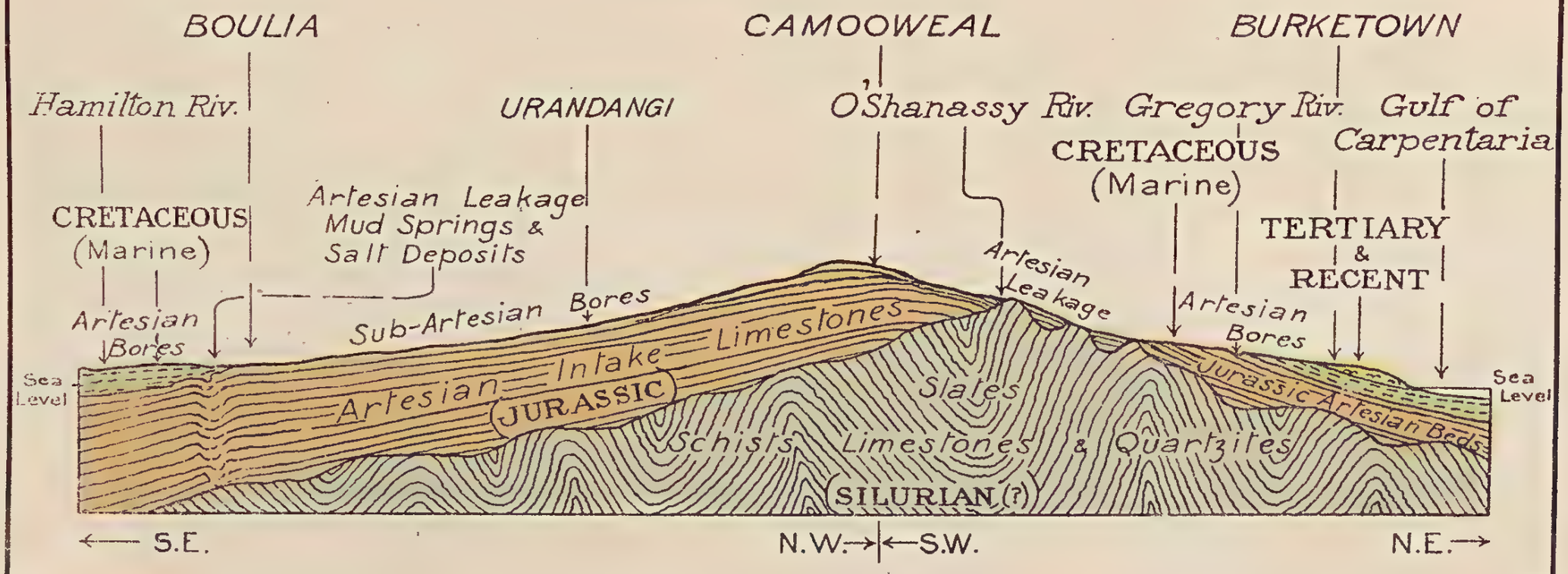
Inoceramus sp., Williams River; *Inoceramus marathonensis,* Devoncourt; *Inoceramus Cripsii,* Toolebuc; *Aucella hughendenensis,* Mulligan River, Warenda, Kamileroi, and Toolebuc; *Fissilunula Clarkei,* Gregory River; *Crioceras flindersi,* Toolebuc; *Haploceras flindersi,* Warenda; *Haploceras Daintreei,* Toolebuc; *Nautilus Hendersoni,* Mulligan River; *Belemnites Canhami,* Toolebuc; *Belemnites sp.,* Williams River, Kamileroi, and Coolulah; *Cephalopods,* Julia Creek; *Natica Jackii,* Julia Creek; *Corax australis,* Warenda; *Portheus australis,* Dugald River; *Lamna appendiculata,* Kamileroi; *Notochelone costata,* Warenda; fossil shells, Mount Datson.

Upper Cretaceous (Winton) Series.

The Upper Cretaceous (Winton) beds cover an immense area of country in the western, southern, and south-western portions of the State. Their line of junction with older beds extends from the north of Winton to the south-west along the

BOULIA-CAMOOWEAL-BURKETOWN SECTION

(DIAGRAMMATIC)



Section About 500 Miles in Length

W. H. R. Del

Plate 4

MINES DEPT.

Diamantina River into South Australia, while to the south-east of Winton the boundary extends to Muttaburra, then to the west of Longreach and towards Tambo, Charleville, and Surat, passing into New South Wales about Goondiwindi. To the north of Winton there is an irregular development of patches of the Tertiary beds which overlap the marine beds, while at Winton the beds are a few hundred feet thick with a gradual and irregular thinning out to the north and a thickening towards the south-east and south-west. At Terrick Terrick Station, to the west of Tambo, they are about 1,000 feet thick and at Charleville and south-east of Surat they are apparently 2,000 feet thick, while at the New South Wales border about 40 miles west of Goondiwindi an area exists where the beds are about 2,000 feet thick with a gradually lessening thickness all round.

Coal having lignite characters is present in this Series at Winton, and although nothing definite is known regarding its occurrence and extent, it has been found in the bore at Terrick Terrick and also at several localities on the Barcoo and Thomson Rivers southerly from Longreach. It may be stated that coal is also found in bores between Charleville and Cunnamulla on the Warrego River, near the Maranoa River to the south of Mitchell, and at Goondiwindi on the MacIntyre River, but these occurrences are in the Jurassic beds below the Cretaceous marine beds and not in the Winton Freshwater Series above.

The Winton Series would be the equivalent of the lignite-bearing Patchawarra Beds in South Australia, but much younger than both the Cabbage-tree Creek (? Jurassic) beds north of Cloncurry containing hydrous coal and the Sandringham brown coal impregnated with pyrites.

Fossil evidence regarding the age of the Winton Series is very meagre. Fragmentary dicotyledonous leaves and Unios occur in a ferruginous rock four miles north-west of Winton, while at Birdsville *Zamites ensiformis* Eth. has been recorded.[26] *Isodora* and *Helix* with mammalian and reptilian remains have been found in limestone at Riversleigh on the Gregory River about lat. 19°[27], but this locality is within the belt of the Cloncurry Mineral Series and no doubt the limestones there have been formed from the denudation of the local rocks. The fossils are considered by the late Mr. Etheridge, of the Australian Museum, Sydney, to be Tertiary or Post Tertiary in age.

[26] Contributions to the Palæontology of South Australia. R. E. Etheridge, jun. In Report on Explorations in the Western Part of South Australia. By Auth. Adelaide. 1898.

[27] Danes. *Loc. cit.*

At Mended Hill, between Riversleigh and Lawn Hills, Mr. Ball found *Dentalium*, which is probably of the same age as the fossils found at Riversleigh.

Fossil Localities.

Boulia.

Jurassic—

Tree-fern. Curridgee Water Hole, 17 miles S.W. of Boulia.

Cairns Range.

Silurian—

Actinoceras sp. ind.
Bivalves.
Orthoceras sp. ind.
Orthoceratites sp. ind.
} Head of Mulligan River near border of Northern Territory.

Camooweal.

Post Tertiary—

Isidora c.f. pectorosa.
Therrites fosteriana Eth. fil.
} Carl Creek, junction of Gregory and O'Shanassy Rivers, Riversleigh.

Cloncurry.

Silurian—

Stromatopora sp. Pumpkin Gully, 12 miles east of Cloncurry.

Cretaceous—

Inoceramus sp. 8 miles W. of Williams River, on main road 24 miles E. of Cloncurry.

Belemnites sp. 1 mile N. of Williams River Crossing, main road.

Devoncourt.

Cretaceous—

Inoceramus marathonensis Eth. At Station, 40 miles S.S.W. of Cloncurry.

Dugald River.

Cretaceous—

Portheus australis. Woodward. Granada Station, 40 miles N. of Cloncurry.

Gregory River.

Post Tertiary—

Tellina sp. Head of Gregory River, Barkly Tableland.

Julia Creek.

Cretaceous—

Natica Jackii Eth. fil.
Cephalopods.
} Near Railway Station on Richmond-Cloncurry Railway.

Kamileroi.

On the Leichhardt River.

Cretaceous—

Aucella hughendenensis Eth. Near mouth of Gunpowder Creek, a branch of Leichhardt River.

Belemnites sp. In limestone 9 miles from mouth of Gunpowder Creek.

Lamna appendiculata Agassiz. In limestone at Kamileroi Station.

LEICHHARDT RIVER.

Cretaceous—

Belemnites sp. Collulah Station.

Post Tertiary—

Euowenia grata De Vis.
Macropus magister De Vis.
Pallimnarchus pollens De Vis.
Pascolomys Mitchelli Owen.
Pascolomys gigas Owen.
Simoprosobus trilobus McLeay.
} Loc. indefinite.

RIVERSLEIGH STATION,

Gregory River, on lat. 19° S.

Post Tertiary—

Diprotodon minor Huxley. Near Verden Rock, Riversleigh Station.
Isidora c.f. pectorosa. Top of Conical Hill, Riversleigh Station.
Isidora sp. Tarpein Rock, near Riversleigh Station.
Helix sp. Tarpein Rock, near Riversleigh Station.

MULLIGAN RIVER.

Cretaceous—

Aucella hughendenensis Eth.
Nautilus (Cymatoceras) Hendersoni. Eth. fil.
} 110 miles S.W. of Boulia, 35 miles W. of Sandringham Station.

TOOLEBUC.

Cretaceous—

Aucella hughendenensis Eth.
Crioceras flindersi McCoy.
Haploceras Daintreei Eth.
Inoceramus Cripsii Mantel.
} Toolebuc Road, 10 miles S. of Beaudesert Station.

Belemnites Canhami Tate. Toolebuc No. 12 Bore.

WARENDA.

Cretaceous—

Corax australis Chapman. E. side of Hamilton River at crossing of Boulia-Winton Road.

Fossil shells. Boulia Road, 7 miles E. of Hamilton Hotel.

Fish remains. On Black Ridge near Boulia Road close to Dinner Creek and near Hamilton No. 10 Well, 4 miles E. of Polygamnon Creek.

Aucella hughendenensis Eth.
Haploceras flindersi McCoy.
Notochelone costata Owen.
} 34 miles E. of Boulia.

Fossil shells. Mount Datson, 12 miles N. of Warenda.

WARENDA.

Tertiary—

Diprotodon? Teeth. Bathunga Springs. Warenda, 45 miles N.W. of Boulia.

Mud Springs.

Several occurrences of mud or mound springs have been recorded in the western part of Queensland, South Australia, and Northern Territory in country which is either artesian or sub-artesian, and, from the evidence collected, there is no doubt that they have a direct connection with artesian flows. It is also noted that the springs, so far as Queensland is concerned, are exclusively confined to lower Cretaceous strata, or to beds equivalent to this marine series, and apparently the same rule holds good in New South Wales and South Australia. Many of the springs are close to outcrops of old rocks, but the marine beds or their equivalent are in the vicinity. They form the actual impervious cover to the water-contained strata and hence the close association of mud springs and marine fossils.

Mud springs at the Hamilton River are noted for the deposits of bluish or blackish mud which usually accumulate around the vent in the form of a mound, the colour no doubt being derived, in the case of the black mud, from the coaly material occurring in the artesian strata in this district. The mounds are usually a few feet high, but some are much higher, while extinct ones are known which are 50 feet high. Sometimes a core, quite hard and shrunken on its surface, forms as a blister or as a loose cap to the soft mud below, while in other instances a soft core is slowly ejected without forming a mound. No definite line of weakness is apparent in the artesian strata above which the mud springs occur, and probably the escape of water to the surface is through beds which have been irregularly crushed or crumpled rather than faulted. It was thought at first that the leakage was due to a local denudation or a tapering out of the impervious overburden to the water-bearing beds, but the depth at which the water occurs in the bores on either side of the area of mud springs shows that this is not necessarily the case.

At Warenda, to the east of Boulia, the artesian bores generally tap the artesian flow at depths averaging about 500 feet, with a flow occasionally at a depth of 50 feet, or even less. The shallow supply has been thought to be the result of this local thinning out of the artesian strata and that the artesian water horizon is in consequence near the surface. An inquiry on the subject, however, showed that Cretaceous marine beds occur at several places in the locality, and unless some abnormal condition prevails, such as a severe rolling or crumpling, the shallow bed could not very well belong to the ordinary artesian strata and is more likely to be a portion of the marine series above them.

The shallow bores are within or near the mud spring area, and probably a bed above the level of the artesian strata has been charged with water under pressure from the same source as the water in the mud spring. This upper bed no doubt is covered by impervious rock and the water contained in it has been prevented from reaching the surface. In other words the water from the main artesian beds has been forced through a leakage channel, perhaps at the contact of an older formation, to an upper stratum in which it has remained under pressure. With the wearing away or disturbance of this impervious bed a spring would form, but with the impervious cover intact a flowing supply would only result if a hole is drilled through the bed.

On one side of the area, that is to the north-west of the Hamilton River—the local intake side—the artesian supply is small, while on the south-east side the flows are good and the behaviour of the bores coincides with those further east towards the centre of the artesian basin. No doubt the sluggishness of some of the bores in this locality is due to the leakage at the mud springs. A section is given on Plate 4 which illustrates these features, and on Plate 5 a section of the country about Sandringham and Lake Ameroo, near the Mulligan River, shows somewhat similar structures.

At Springvale, about 80 miles E.S.E. of Boulia, there are a number of artesian leakage vents and good examples of the mud mounds are said to occur there, to see which a deviation of 50 miles is necessary from the Boulia-Winton road. At Elizabeth Springs, 60 miles from Boulia on the same road, other splendid examples are to be seen, and Mr. Calvert, of the Water Supply Department, estimates that 40 mounds exist within an area of about a square mile in that locality.

Between the Georgina River and the Northern Territory border at New Carlo, an outstation south-west from Glenormiston, some large mud mounds have been formed by the springs, and one is said to be 15 feet high. Usually fresh water is ejected from the springs, but in certain localities, references to which will be made under the heading of "Salt," the water ejected is very saline. On Plan 1 is shown the localities in Western Queensland where these mud springs are reported to occur.

Another group of mud springs occurs at Eulo, to the east of Thargomindah, in proximity to granite outcrops associated with mica schist. In this locality there is a marked difference in the depths of the bores, one being 1,740 feet deep with a flowing supply of water at 1,546 feet, and only a short distance from a

mud spring, with another bore a little further away obtaining a flowing supply from a depth of 220 feet. Like those at Warenda the shallow bores probably derive their supply direct from beds above the artesian belt—which are probably the Cretaceous Marine Beds, although up to the present time marine fossils have not been found in them.* No doubt a channel exists at the contact of the mass of schists and granite with the edges of artesian and marine strata, through which the water rises into the upper beds and remains there under pressure, or otherwise flows over at the mud springs.

It is unreasonable to suppose that the base of the artesian beds about Eulo rises up to conform with the slope of the granite or that the beds become attenuated at the edges as has been suggested. The mass of granite and schist is probably the equivalent of the Cloncurry mineral belt and was no doubt elevated to its position long before the artesian strata were deposited. A gradual accumulation of horizontally-bedded sediments probably took place on the irregular slopes of the granite and schist, and gradually overwhelmed them, and it is in this irregular contact area that the leakage upwards now takes place to the mud springs.

Reference is made under separate heading to the formation of "Quartzite" and "Opal" in the vicinity of mud springs and leakages.

Salt Deposits.

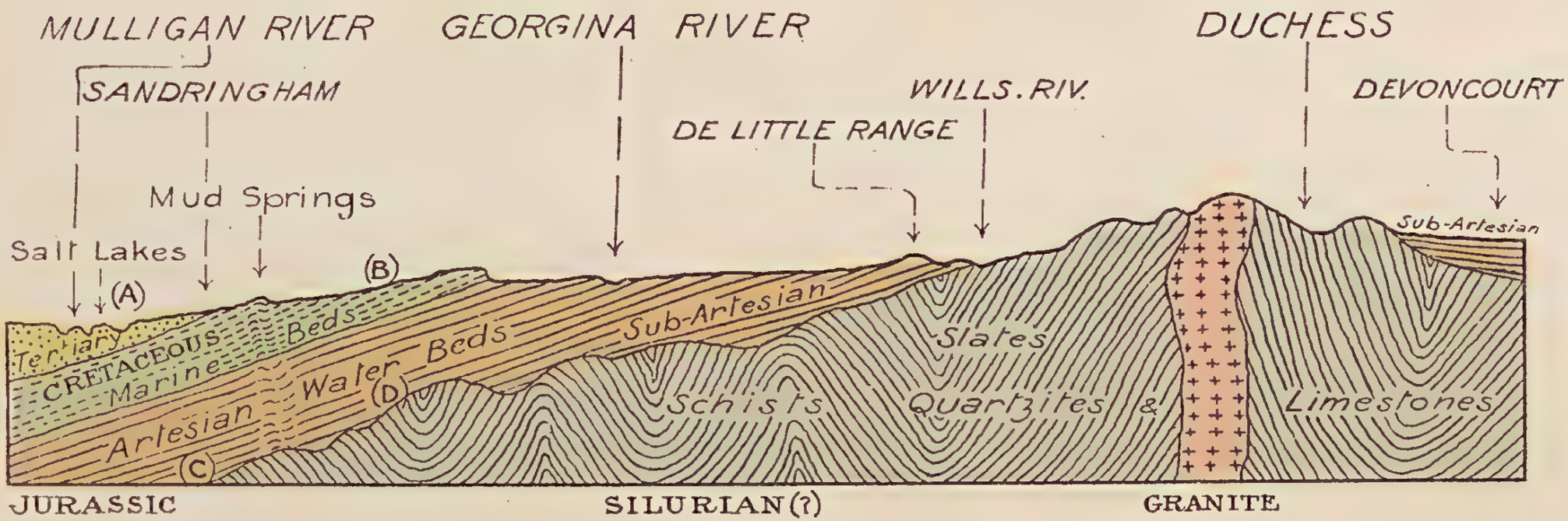
The occurrence of surface deposits of salt about Georgina and Mulligan rivers is evidently due to a leakage of salt water from artesian water-bearing strata, and is not a result of the evaporation of drainage water from surface rocks. Sub-artesian water in the bores to the north-east of the Georgina River and in the vicinity of the Hamilton River on Warenda Run is free from salt, while the bores to the south-west on Sandringham Run, as shown on Plate 5, contain water which is either salt or brackish. Several bores on Sandringham are very saline, and three or four are said to contain saturated brines.

The mud or mound springs about Lake Ameroo, on the Mulligan River, indicate that some stratigraphical irregularity or disturbance exists which allows the water to percolate to the surface and deposit its salt, and the evidence in general shows that the artesian supply in one area is salt and in another fresh and that the mud springs in producing salt or fresh water according to their positions are indicative of their close connection with artesian water and salt deposits.

* Since found by Mr. Ogilvie of the Water Supply Department. B.D.

MULLIGAN RIV.-GEORGINA RIV.-DUCHESS SECTION

(DIAGRAMMATIC)



S.S.W. —— Length of Section about 170 Miles —— N.N.E.

(A) Saltwater Lakes Sth of Mud Springs (B) Freshwater Lakes Nth of the Mud Springs

(C) Freshwater in Bores Sth of Mud Springs (D) Saltwater in Bores Nth of the Mud Springs

W.H.R. Del.

Plate 5

It may also be stated, by the way, that the whole of the cavernous limestone country between the Hamilton River and Camooweal—*i.e.*, the country drained by the north-eastern branches of the Georgina River—is free from salt, unfortunately for the pastoralists. There is a rapid absorption of all surface water, and anything soluble in the surface rocks which might result from mineral decomposition is leached out. There is also very little surface evaporation, and consequently no local surface accumulation of salt.

The absence of salt in the Camooweal district and its presence about the Mulligan River (the former being an intake area, the latter a leakage area) suggests, in conjunction with the other features mentioned above, that the Mulligan salt deposits are obtained from water taken into the artesian system about Camooweal. They are therefore a direct result of the leaching of the limestone covering this immense area, which below the surface must contain traces of salt.

Lake Kallidiwarry, at the junction of the Mulligan River and Eyre Creek, about lat. 25°, is said to contain more salt than any other locality in the district, and many thousands of tons of the mineral are supposed to be buried below deposits of recent alluvium. The lake or lagoon is 12 miles long and 100 yards wide, and in places is said to contain a thickness of 4 feet of salt, while around about there are a number of smaller isolated dried lakes all containing salt beds.

Lake Philippi, between the Mulligan River and Eyre Creek, is generally thought to be a salt lake, but this is a mistake as the water is quite fresh. The country in the vicinity, however, is said to contain innumerable salt deposits, and in the small lakes situated between 20 and 25 miles to the west and south-west large quantities are known to exist.

In the flat country about Burketown the lakes and lagoons connected with tidal rivers along the coast of the Gulf of Carpentaria contain salt deposits. These accumulations are the result of solar evaporation, which is very intense in this part of the State and very pronounced during the south-east winds in winter time.

The approximate annual rainfall about Burketown is 28 in., the evaporation being 100 in., or a net evaporation over rainfall of 72 in. Between November and April the rainfall is 27 in., the evaporation 60 in. and the net evaporation 33 in., while the cold half of the year has an average rainfall of about 1 in., an evaporation of 40 in. and a net evaporation of 39 in. Victorian

statistics show the most favourable localities in that State to have an annual net evaporation of only 18 in. and a summer net evaporation of 17 in., so that the great advantage of Burketown in this respect can be at once realised. The dry season of the year in the north of Queensland is in winter and in Victoria is in summer, this effect being due to the difference in the time of the year when the evaporation and rainfall is greatest in these extreme positions in Australia.

Localities where salt accumulates about Burketown are very numerous, and during the rainless winter white sheets of salt form everywhere on the clay-pans, although with the summer rains most of the deposits are washed away.

Wild Horse Creek, on Escott Run, about 27 miles north-westerly of Burketown (see Plate 1) is the most noted locality for salt and all the consignments of coarse salt from Burketown to inland stations are obtained from this source. Other large deposits are said to exist further north-west along the coast and their continuation has been traced into the Northern Territory to the McArthur River.

The natural conditions as regards tides and the immense extent of clay-pan country along the Gulf coast are also factors which should induce those interested in the matter to undertake experimental work in the manufacture of salt by solar evaporation.

Coal Deposits.

In North-Western Queensland the absence of the palæozoic formations which in Eastern Queensland contain workable seams of coal is very pronounced, and the only possible source of a coal supply in this part of the State is the artesian water-bearing Jurassic beds. On the Darling Downs the strata of this age contain both coal seams and artesian water, and no doubt in many of the localities where artesian bores have been put down the water problems have received all the attention while the coal seams have been neglected.

In the past the coal occurrences in bores were recorded very unsystematically, and even now much more scientific data should be forthcoming regarding the character of the seams of coal which borers simply make a note about. Such information may have no particular value in the majority of places, but it helps to link up localities where coal has been found, and altogether may have an important bearing on some problems concerning economic coal supplies, specially in Western Queensland with its various railway trunk lines.

Outcrops of the coal-bearing Jurassic beds have been observed at Cabbage Tree Creek in the Cloncurry District, and coal seams have been passed through in artesian bores about the Georgina and Hamilton rivers. Cabbage Tree Creek is a branch of the Leichhardt River about 41 miles N.N.W. of Cloncurry, and is crossed by the Cloncurry-Dobbyn Railway line, the coal occurring about 7 miles south-west of the line in a shaft originally sunk for water. The quality of the coal is fair, as shown from the analysis given below, and although the seam is only a few inches thick every encouragement should be given to prospect the area by boring, as a good seam of coal would be exceedingly valuable if discovered hereabouts.

About Cabbage Tree Creek very few natural sections showing stratification are to be observed, so that nothing can be suggested regarding the probable extent of the measures or whether other seams exist. At the same time the whole of the eastern side of the Cloncurry mineral belt (see Plate 1) is an artesian outcrop and inferentially a possible coal field, and consequently when boring operations for artesian or sub-artesian water are in progress, the material brought up from the bores should be scientifically examined and recorded.

CABBAGE TREE CREEK COAL ANALYSIS.

Moisture	9.1%
Volatile Hydrocarbons	23.9%
Fixed Carbon	56.4%
Ash	10.6%

Coal is non-coking.

This analysis shows the coal to be hydrous and to be non-coking, both defective features in some respects, but otherwise it has gool qualities and would certainly be much in demand if produced in large quantities. The value of the factors to be considered in determining whether seams are payable to work of course varies with the locality, but a seam of coal 2 ft. thick having the above composition would certainly be a payable proposition in this district if worked economically.

Mr. McIntyre, an experienced well-borer, states that in several of the artesian bores sunk about Sandringham to the west of the Georgina River he has met with 6 ft. of brown coal much impregnated with iron pyrites and that it is closely associated with the water-bearing beds. This coal is of course below the geological horizon of the Cretaceous Marine Beds of the Mulligan River and would be equivalent in age to the coal

measures at Leigh's Creek in South Australia, with which it probably is connected by trending south-westerly across the border to beyond Charlotte Waters and Oodnadatta and then south-easterly to Leigh's Creek. Similar deposits of brown coal occur in the bores on the Terriboah Run to the east of the Hamilton River near the Georgina River Junction. They have an inclination to the south-east and probably have a connection in this direction, or more to the south, with the Leigh Creek measures by passing under the marine beds.

The coal seams occurring in the Winton Series do not appear to be of much value, so far as developments have gone, and the prospecting for coal at Winton itself some years ago was quite a failure. Other places to the south of Longreach have not been tried although coal is known to occur in some of the bores there, the prospects not being considered encouraging on account of the comparatively recent age of the beds.

Mineral Features.

Copper.

During the recent inspection of the geological features of the Cloncurry Field no attempt was made to obtain details of the occurrences of the copper lodes, except the one at Mount Oxide. General references are made on a previous page to the publications issued covering the lodes, but the work of Mr. Ball is the latest, having made an examination of nearly all the mines on the field during the year 1908. His report is in two parts, the first one of 42 pages containing the introduction, bibliography, history, and an account of the geology of the field, the second part of 380 pages being a detailed description of the copper mines, their development, ore-bodies, mining and geological features and prospects. The following copper mines were visited and reported on by him:—Mount Elliott, Duchess, Trekelano, Hampden, Wee MacGregor, Argylla, Native Companion, Surprise, Mount Cuthbert, Mighty Atom, Crusader, Dobbin, Mount Oxide, and many others, the whole of which are compressed in 85 copper mining groups. The report is accompanied by 76 small text plans and 26 figures, together with a small map of the districts on a scale of 18 miles to 1 inch, showing the geological boundaries and the geographical positions of the copper mining groups.

The recent inspection of Mount Oxide by the writer was specially undertaken to determine whether a favourable opinion

could be formed of the mine in view of the proposal to connect the mine by railway with the trunk line extension beyond Dobbin, to the north of Cloncurry.[28]

MOUNT OXIDE COPPER MINE.

General.—The Mount Oxide Copper Mine, belonging to the Mount Elliott Company, is situated in a direct line about 112 miles N.W. of Cloncurry and about 45 miles W.N.W. from Kamileroi on the Leichhardt River. The nearest railway station is Dobbin, about 72 miles northerly from Cloncurry, from which there is a road connection to the N.N.W. across Mistake and Gunpowder Creeks to Myally Creek, and then S.W. along the precipitous Myally Gorge to Mount Gordon and Mount Oxide. Another route is by road from Dobbin to Lorraine Station, which is further north than Kamileroi on the Leichhardt River, and then to the western side of Myally Creek, this way being longer but not so rough as that through the Gorge. (See map of the field on Plate 1.)

The Myally Gorge is undoubtedly rough for vehicular traffic in its present condition. It could be made much better with proper road construction, as the grades are not very steep, while the building of a railway through it would not present any engineering difficulties.

Geological Features.—The geological formations about Mount Oxide are quartzites, slates, and schists, the quartzites forming very high and rugged ridges which alternate with the less prominent landscape features produced by the slates and schists. The repetitions of quartzites and slates are very pronounced, and the trending and folding of the rock structures are sometimes observable great distances away.

In the immediate neighbourhood of Mount Oxide are to be seen a number of quartzite belts, one in particular forming a prominence along the course of the copper lode. Alternating with this are to be seen clay slates and a formation which might be described as a friable carbonaceous shale, while wedged in between the slates and the quartzite in the northern end of the worked portion of the lode is the precipitous mass of very pure red oxide of iron from which the mine has received its name. (*See* Plate 6, the small general plan of Mount Oxide Copper Mine.)

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[28] Since this was written the Report of the Commissioners to inquire into the building of the railway has been published, in which a recommendation is made to run a line from Dobbin to Gregory Downs and Burketown to the north-west, with a tramway extension to Mount Oxide from Myally Creek.

The Mount Oxide lode trends south-westerly and north-easterly, and the portion more particularly examined is that between Camp Creek to the south-west and Cave Creek to the north-east. Beyond Camp Creek the lode is well-defined but no work has been carried out on it, while to the north-east of Cave Creek there is a pronounced outcrop of what might be a continuation of the Oxide lode. The configuration of the country hereabouts is rugged, however, and the behaviour of the lode cannot be ascertained until further work has been expended on it.

The precipitous outcrop of red oxide of iron appears to have formed where the lode has been crumpled or otherwise disturbed, and as this mass of hematite undoubtedly will have effected some change in the behaviour of the lode, developments in this direction will require careful attention later on.

The operations which have been completed show that the lode lies parallel with the strike of the rocks and with which it also conforms in its steep inclination to the south-east. The country on the south-east or hanging-wall side is mainly composed of ferruginous and calcareous slates and schists, on the north-west end of which, however, the hematite mass referred to sends out a long gradually narrowing tongue between the lode and the slates. On the other side of the lode—the foot-wall side—carbonaceous shale extends from one end to the other, so far as the workings show, but is interrupted in places by ferruginous non-carbonaceous slates and by irregular masses and lenses of quartzites. (See Plate 7, an underground plan of the central part of the Mount Oxide Mine and Plate 8 showing a cross section of the workings.)

The slates and hematite on the hanging-wall do not contain copper, but the carbonaceous footwall is impregnated with it close to the lode proper, the copper percentage gradually diminishing, however, as the distance from the lode increases, until at about 100 feet west it is entirely absent from the carbon-bearing rock. Further west in the footwall country there are, apparently, alternations of slates and quartzites judging from the outcrop on the western side of the lode.

Longitudinally, the character of the rocks at the south end varies somewhat from those at the north, the south end rocks containing the carbon element alternating with veinlets and small masses of quartzite and ferruginous slate on the footwall side, while the hanging-wall rock is slate, more or less ferruginous and calcareous. At the north end the footwall is carbon-bearing slate and clay slate, and the hematite of the hanging-wall becomes thicker as it approaches the main mass to the north-east.

PLAN Nº1

of

Mt OXIDE COPPER MINE

illustrating

Report by B. DUNSTAN. Chief Gov. Geologist

on

NORTH WESTERN QUEENSLAND

Scale of Feet

0 100 200 300

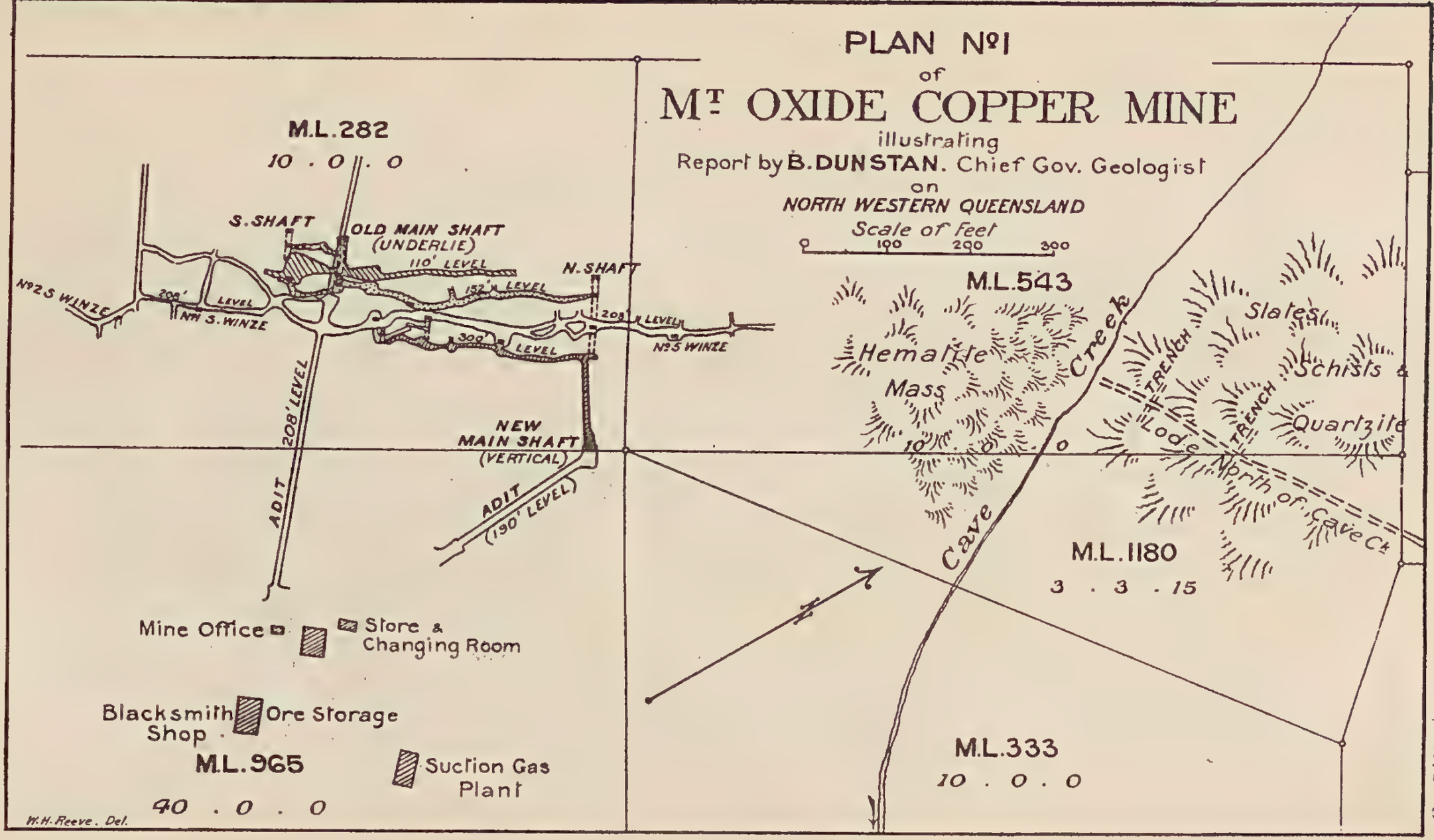


Plate 6

The lode itself, formed on the bedding plane of the sedimentary rocks, is made up of a formation of varying composition, of which the most pronounced rocks are quartzite, slate, and carbonaceous shale. The width of the lode is difficult to estimate, as the dimensions depend on what would be considered payable to work, some of the ore being exceedingly rich, while other portions—those on the west side—are so low in value that they can hardly be considered to be ore at all. However, the company's estimate of the width of the lode, which is 18 feet, may be taken as a fair one, as in places the width is far beyond this limit. (See Plate 8.)

Mining Operations.—The mine workings consist of five levels, two adit crosscuts, several smaller crosscuts, a main shaft, three subordinate shafts, and a number of winzes. The main workings are the adit crosscut at 208 feet, and the levels running north-east and south-west from it along the lode. Below this is the 300-foot level worked from the main shaft, and above it are the 152-foot level, the 110-foot level, and the top level at 60 feet. There is an old main underlie shaft connected with the three top levels, the latter communicating with the adit level by means of winzes. The north shaft is an old working connected with the 152-foot level and the adit level, and it also connects with a winze below the adit level. The accompanying Plan 1 will give a general idea of the underground working, while Plan 2 shows more in detail the portion of the workings where the rich ore occurrences have been mapped.

The total length of the adit level is about 840 feet, the length of the 300-foot level being 250 feet, the 152-foot level 360 feet, and the 110-foot level 290 feet. The cross section on Plate 8 shows the position of the adit level, the 300-foot level below, and other levels and winzes above.

No attempt was made to check all the results of the company's assay samples, but several were selected at irregular intervals on all levels, from which an estimate was made as to the reliability of the company's assay plan submitted for inspection. Of course there was a variation in the results from the two samplings as the ore values are very high in some places, and the difference of 2·2 per cent. of copper in the general average was small in view of the limited number of samples recently taken in comparison with the large number previously taken by the company.

The assay results indicate a rich zone or shoot of ore lying between the south shaft (see Plate 8) and the north end of the

110-foot level, the south end of the shoot appearing to dip northerly from the south shaft to the southern end of the 300-foot level, while the northern end of the shoot apparently dips from the northern end of the 110-foot level to the northern end of the 300-foot level, the latter position being at the junction of the 300-foot main crosscut. The workings along the 208-foot level within the limits given correspond with the levels above and below so far as values are concerned, and the values in all the levels show that the ore shoot will assay on an average 20 per cent. of copper.

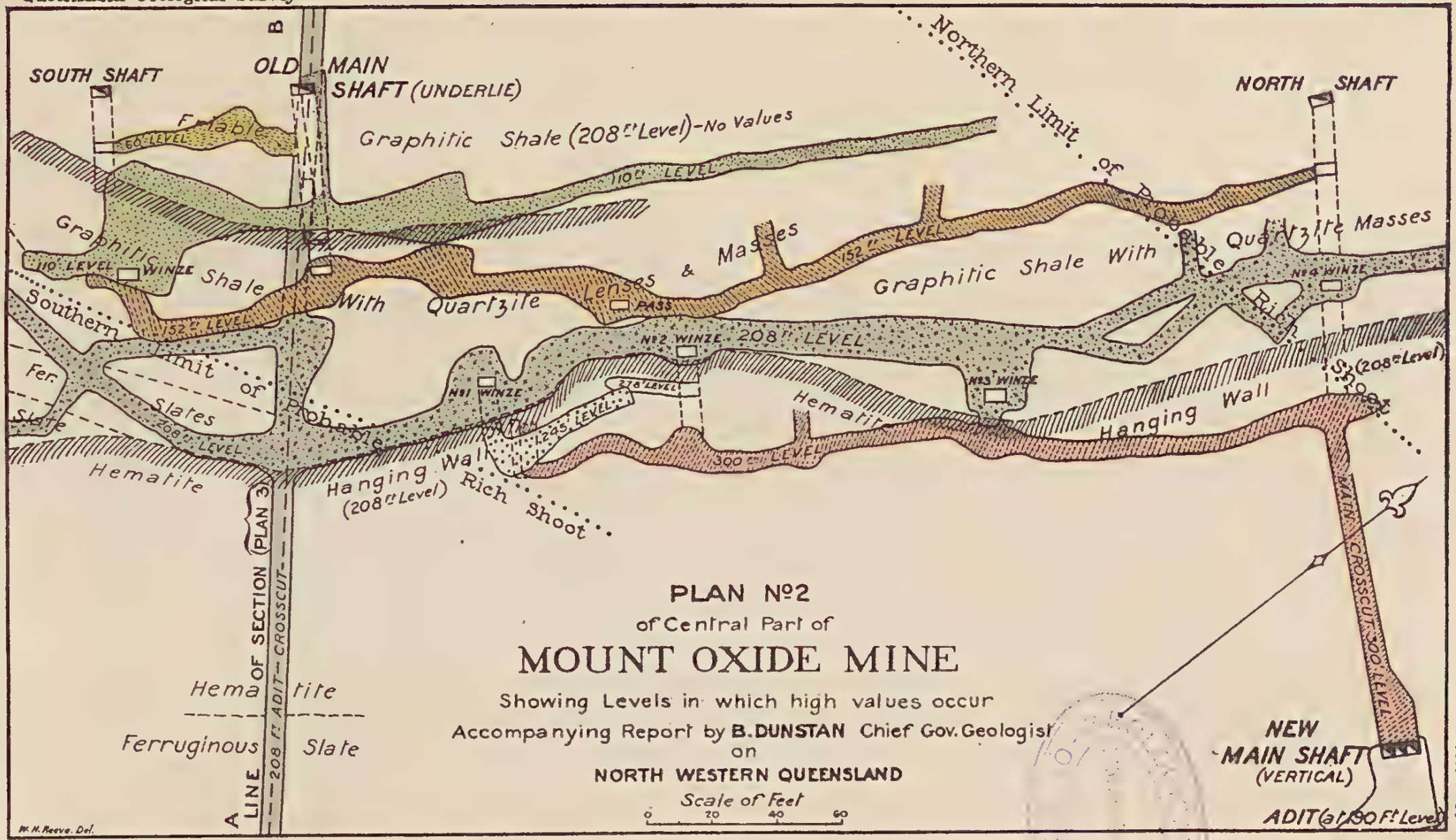
Regarding quantities, the rich shoot of ore contains, roughly, a block 250 feet long, 300 feet deep, and 10 feet wide (where actually exposed), in which there is a reserve of over 50,000 tons of ore containing 20 per cent. of copper.

The lessening values as the distance increases from the eastern wall suggests that the next 10 feet of ore, with the same dimensions as above, also contain 50,000 tons, but with an average content of 15 per cent. of copper. A third section of 10 feet would yield 50,000 tons of 10 per cent. ore, and a fourth section would yield a similar amount of 5 per cent. ore, making up a total of 200,000 tons of ore having a general average of $12\frac{1}{2}$ per cent. of copper.

Below the 300-feet level no work of any kind has been undertaken, an extraordinary neglect in view of so much work being performed above this level and also about Cave Creek, which, although very useful, has no immediate practical application. The neglect might be construed into a want of confidence by the management in the deeper development of the mine, although there is nothing in the mine which should suggest the idea.

Concerning the ore in the southern workings at the 208-foot level, it is very evident that an immense deposit exists here containing an average of 4 per cent. of copper. Crosscuts to the south have revealed about 140 feet as the maximum width of the ore body, which apparently increases in width to the south but diminishes to the north. This impregnated zone, for such it appears to be, probably extends to the surface, as the outcrops show the same general characters, and, judging by its appearance and behaviour along the line, no doubt extends to greater depths.

The ore in the northern end of the same level, that is beyond the rich shoot which seems to end at the north shaft, also shows an average of 4 per cent. of copper, and were it not for the apparent disturbance in the lode beyond the workings in this vicinity, one would feel inclined to look at this end with as much



PLAN No2

of Central Part of

MOUNT OXIDE MINE

Showing Levels in which high values occur

Accompanying Report by **B. DUNSTAN** Chief Gov. Geologist

on

NORTH WESTERN QUEENSLAND

Scale of Feet

0 20 40 60

Plate 7.

favour as the south end. As it is, 150 feet along the lode around No. 4 winze and immediately north show a general average of 5 per cent. of copper, and the cross-cut westerly in this section of the northern end of the level averages even more than this percentage.

The extreme end of the level shows very low values, and in some of the exposures there is not a trace of copper. The disturbance mentioned appears to have opened or loosened the country, and the same weathering agencies which bleached the slate at the end of the workings also leached out the copper, so that on the other side of the trouble it is probable that the copper will make its appearance again. This disturbance may be associated with the large mass of hematite referred to, and if this level is continued northerly to Cave Creek the actual conditions will then be revealed.

Regarding the character and richness of the lode below the 300-foot level, very little data is available to work upon, but the persistence of the rich shoot between the north and south shafts, and extending from the surface down to 300 feet, warrants the assumption that unless some extraordinary structural or mineralogical change takes place, of which, however, there is no indication, the richness will continue below this level and the shoot will probably be inclined towards the north. (See Plate 8.)

If this assumption be correct, the main shaft would intercept this shoot of ore if it were deepened a couple of hundred feet and short crosscuts put in westerly at what would be the 400-foot and 500-foot levels. Otherwise, the lode might be followed below the 300-foot level by a continuation of the No. 3 winze sunk down to this level from the 208-foot level above.

The diminishing of the copper values as the distance westerly increases from the main ore body appears to be associated with the occurrence of quartzite patches and lenses in the carbonaceous shales. The copper disappears as the quartzites disappear, and the carbonaceous shales to the west, where free from this siliceous formation contain no trace of the metal. Along the 208-foot adit crosscut these carbonaceous shales at a steep angle rest on ferruginous slates, which, again, rest on another series of quartzites. The latter are just exposed at the western end of the workings and nearly 200 feet away from the main lode channel.

The copper-bearing outcrop on the north-east side of Cave Creek is not in line with the Mount Oxide lode (See Plate 6), and

if the latter continues on the western side of the hematite mass, as suggested, it will reach Cave Creek, far above (west of) the copper outcrop on the opposite side. If the two lodes are one and the same, then a severe bend or faulting of the rocks and lode in this locality will have been produced. The copper-stained outcrops are exposed in a steep side of the creek, and the trenches which have been cut at right angles with the line of lode show a section containing a great thickness of ore, and in character resembles the Mount Oxide lode formation to the south-west, but carries values probably averaging more than 5 per cent. of copper. In any later scheme for treating low-grade ore, the lode at Cave Creek would require to be brought into consideration, and future operations might reveal it as an important adjunct to the Mount Oxide Mine.

Conclusion.—Generally considered, the Mount Oxide proposition is a very sound one from whichever aspect it is looked at, either as a large body of rich ore or as a gigantic body of low-grade ore. As a rich-ore mine, easy means of transit from and to it would certainly be warranted, and as a low-grade mine of course it would be impossible to do anything without the best possible railway service. Looked at from the point of view of being a valuable State asset, it would be very unwise to allow the mine to be worked simply for its high-grade contents and thereby making the rest of the large ore body too poor for subsequent handling. It would be necessary, however, if facilities were granted or established in the way of railway construction to make some provision whereby the exploitation of exclusively rich ores is prevented, and in any scheme advanced it would be advisable to make it compulsory to treat the low-grade with the high-grade ores.

If such provision be made, then the great problem regarding the economical treatment of vast quantities of low-grade copper ores in the Cloncurry district will have some chance of being solved, but if the old conditions are allowed to prevail, railway facilities will only expedite the robbing of the rich parts and leave the mine in the same regrettable condition that many of the Cloncurry mines are in to-day.

It would also be advisable, looking at the matter from the point of view of future prospecting developments, and bearing in mind the resources of the Cloncurry area, that special geological attention be given to the occurrence of copper and other minerals in the length of 400 miles of country extending north-westerly

PLAN No3

CROSS SECTION OF MOUNT OXIDE WORKINGS

Between A-B Shewn on Plan 2

Accompanying Report by B. DUNSTAN Chief Gov. Geologist

on

NORTH WESTERN QUEENSLAND

Scale of Feet 0 40 80

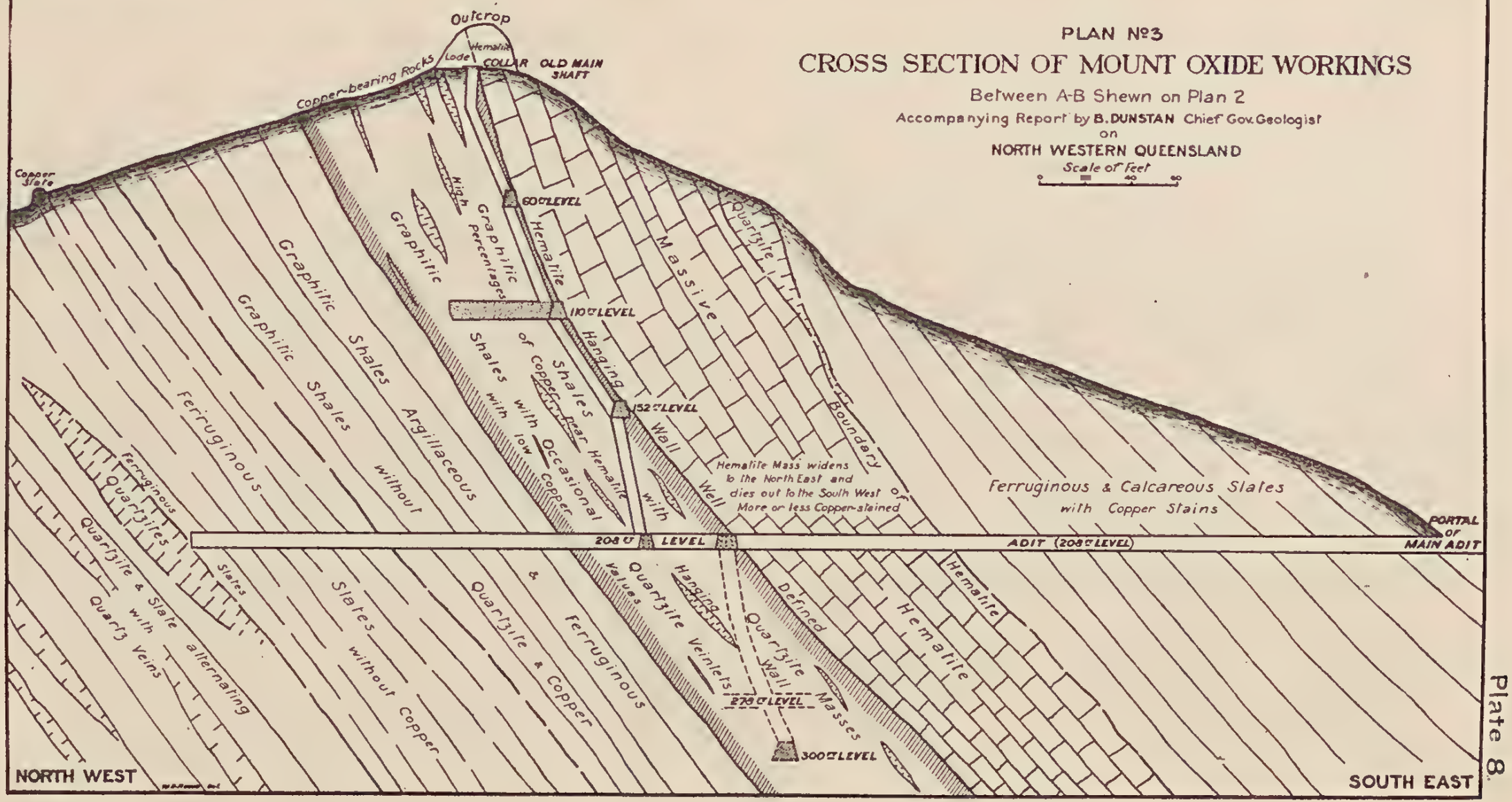


Plate 8.

from Selwyn through Cloncurry, Mount Oxide, and Lawn Hills to the Northern Territory border. This wonderful mineral area has many possibilities in other respects than copper, and it would be decidedly wrong not to specially mention the necessity of carrying out geological work bearing on its mineral occurrences.

The Cloncurry district, at the present time, contains a vast number of small mines which have been quite neglected, so far as their geological examination is concerned, and practically all have been opened and, in most cases, closed again without any data being acquired about the underground work. This is not only neglecting the mineral prospector, who should have all the scientific assistance possible, but it is quite contrary to what should be done in obtaining information about all old workings. In the future we should be in a position to state what was done in the mines and why they were abandoned. All miners know the advantage of having the record of old mines made available as thereby they are often saved much expense and trouble. On such an important field as Cloncurry large mines may be developing on quite wrong lines, and in every way it would pay better to have such work checked to prevent mistakes than requisition the services of a geologist as an afterthought.

Iron Ores.

MOUNT LEVIATHAN.

Mount Leviathan, or Black Mountain as it is called locally, is a prominent landmark just outside the town of Cloncurry, and forms an elevation of about 270 ft. above the surrounding plains. It is a large mass of ironstone associated with quartzites, schists, slates, breccias, and limestones belonging to the Cloncurry (? Silurian) Series, and in outline is an irregular somewhat lens-shaped lode lying at an angle across the upturned edges of the sedimentary rocks, the strike of the lode being north-east and south-west, with the sediments trending north and south.

A very small portion of the hematite is very pure and coarsely crystalline, the main mass containing a high percentage of silica and frequently traversed by veinlets of quartz. Magnetite does not appear to be present in the lode, although magnetic polarity is to be observed in several places.

The composition of the ore may be seen from the following three analyses, the first one of which, lowest in silica, may be

considered typical of the portion of the ore smallest in quantity, the other two being representative of what to expect bulk quantities to be in composition:—

Mount Leviathan Hematite Analyses.

	1.	2.	3.
	Per cent.	Per cent.	Per. cent.
Iron	62.0	56.5	57.1
Moisture	0.1	0.1	0.4
Loss on ignition	1.8	1.2	
Silica	8.9	17.0	17.5
Alumina	2.0	1.4	2.5
Lime	trace	0.2	trace
Magnesia	trace	trace	trace
Manganese oxide	trace	trace	trace
Phosphorus	0.11	0.08	0.06
Sulphur	0.04	0.05	0.006
Titanic oxide	nil	nil	nil

In forming an estimate of the quantity of ore in the lode a cursory examination showed that the deposit could be divided into three sections, of which the southern part probably contains a maximum of 1,500,000 tons, the central and southern portion containing about 500,000 tons, making altogether a total of about 2,000,000 tons.

Mount Philp.

Mount Philp is a range of hills and peaks situated between 2½ and 5 miles south-westerly from Ballara, a railway station 35 miles in a direct line south-westerly from Cloncurry, and 63 miles by rail via Malbon Junction. This series of hills and peaks is made up of enormous outcrops of ironstone, the adjacent rocks consisting of altered sandstones, quartzites, calcareous and ferruginous slates and schists, and crystalline limestones and dolomites. These sedimentary rocks are vertically bedded, or nearly so, with a general N.N.E. and S.S.W. strike, the ironstone lode apparently agreeing with the strata in both trend and inclination.

Parallel with Mount Philp and about a mile to the west is the precipitous Fountain Range, which consists of a narrow belt of indurated sandstone prominently elevated between other softer and more easily weathered rocks. Plate 10 shows in plan the position of Mount Philp and the Fountain Range, together with some of their geological features. Plate 11, figures 1 and 2, and Plate 12, figures 3 and 4, are views of Mount Philp, and Plate 13, figure 5, is a view of the Fountain Range showing the gap between the north and south portions, immediately below which

Plate 9

MOUNT LEVIATHAN

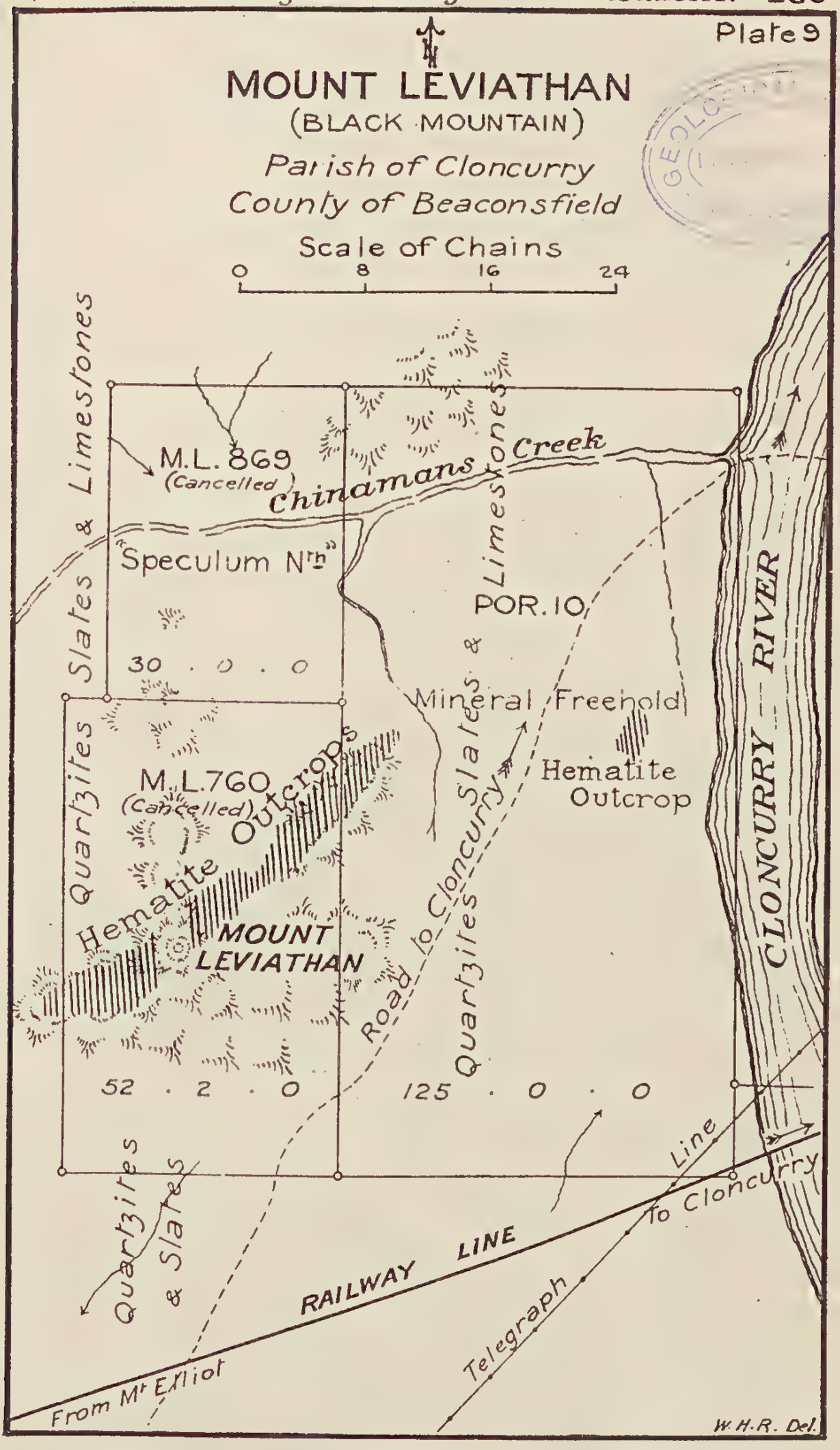
(BLACK MOUNTAIN)

Parish of Cloncurry

County of Beaconsfield

Scale of Chains

0 8 16 24



there is a permanent pool of water. It is said that the country on the western side of this range offers natural facilities for water conservation and that a dam built across the gap, which is very narrow, could be very easily constructed.

The ironstone of the mountain is chiefly hematite with magnetite occasionally present, the impurities consisting mostly of free silica. No place was seen in which the percentage of this substance was not high, but the percentage of other impurities in every part of the lode tested was distinctly low.

MOUNT PHILP IRON ORE ANALYSES.

	1.	2.
	Per cent.	Per cent.
Iron	56.2	52.8
Moisture .. .. .. (at 105°C)	0.2	0.1
Loss on ignition	slight gain	2.3
Silica	19.5	23.0
Alumina	0.7	0.4
Lime	trace	trace
Magnesia	trace	trace
Manganese oxide	less than 0.3	trace
Phosphorus	0.023	0.03
Sulphur	0.01	0.01
Titanic oxide	nil	nil

No. 1 analysis is the average assay result of sixteen samples taken from all portions of the outcrop by Mr. Tregenza, Government Assayer, at Cloncurry. No. 2 sample was taken at the time of the recent inspection and was made up by sampling all the places where the sixteen samples came from. Many years ago, it is said, the mountain was sampled in many parts with a view of utilising portions of the ironstone as flux for copper smelting, and that the assay results showed about 17 per cent. of silica, so that the percentage of this impurity, judging by the recent actual results and an old unofficial report, would amount to just about 20 per cent.

Some consideration was given to the possibility of finding areas of ore on the mountain in which the silica percentage would not be so great, but there is a great uniformity in the composition of the ironstone, that is judging by appearance, and the very minute transparent silica grains could be seen in every specimen examined. It has been suggested that the high percentage of silica might be due to the rain leaching out the iron from the surface outcrops and leaving behind on the exposures an excess of silica. A careful study, however, shows that there is an absence of all porosity and that leaching effects were not

apparent, a feature, no doubt, partly due to the iron oxide being in the ferric condition, the most staple form in which it occurs in nature, and partly to the silica being in a free state instead of in combination with basic substances.

In estimating the quantities of hematite in the Mount Philp lode only a rough method was employed and no doubt a more careful estimate would show a variation in the result, although for all present purposes this approximate estimation is all that need be required. The outcrop of the lode can be observed for miles when viewed from the top of one of the pinnacles (*see* Plate 12, figures 3 and 4), but a length of two miles along the main portion contains all the measureable quantities of ore, outside of which no doubt there are other large quantities, more or less obscured.

Within this limit of two miles the width of the lode varies from 50 to 150 feet, an approximate average being 100 feet, the height varying from 50 feet to 500 feet above the level of Fountain Creek which cuts through the range at the northern end (*see* Plate 10), and 150 feet may be taken as an average in this direction. Within these dimensions there must be at least 10,000,000 tons of easily mined ironstone and another 10,000,000 tons more or less under cover, altogether making an "actual" tonnage of about 20,000,000 tons. The "probable" quantity of ironstone in the lode might be 20,000,000 tons, and the "possible" quantity a further 20,000,000 tons.

The facilities for working the ironstone could be made remarkably easy if the necessity arose at any time, as the lode has been worn down to the level of the surrounding country where Fountain Creek crosses it. A splendid working face has been naturally exposed at this spot quite free from overburden, to which a short railway extension from Ballara could very easily be constructed. Further south and north other precipitous faces are exposed at higher positions, where the ironstone could be quarried very cheaply, and from which shoots or other mechanical devices could convey it to trucks below.

Reference might be made to other iron ore deposits in the district, such as Mount Pisa at Cloncurry, but they become very insignificant in comparison with Mount Philp, and even Mount Leviathan itself may be discarded in view of the great natural facilities for cheap mining at Mount Philp if any scheme were to be adopted to utilise the iron ore.

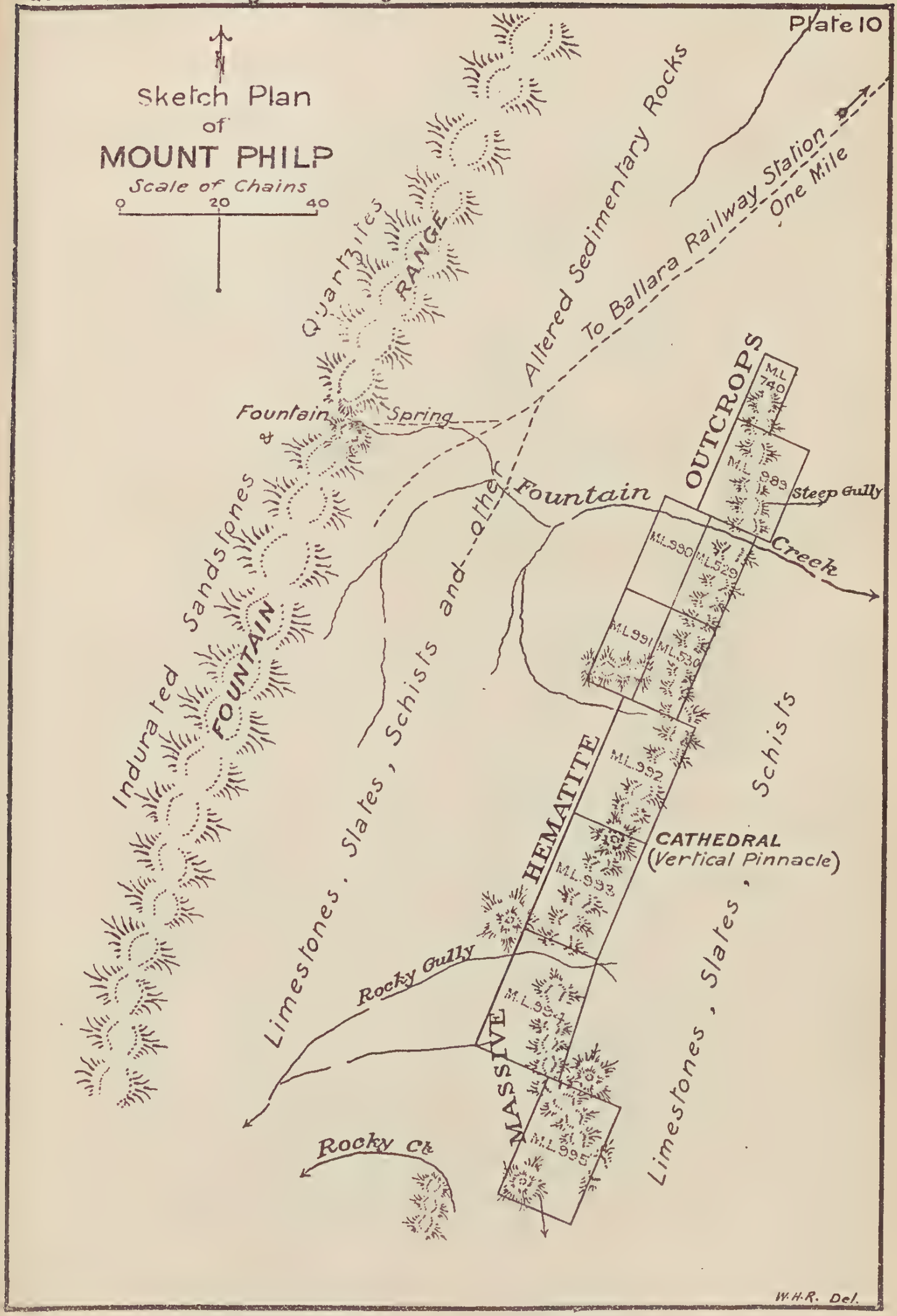


Plate 10
Sketch Plan
of
MOUNT PHILP
Scale of Chains
0 20 40
Quartzites
RANGE
Altered Sedimentary Rocks
To Ballara Railway Station
One Mile
Fountain Spring
Fountain
Creek
Steep Gully
OUTCROPS
M.L. 740
M.L. 983
M.L. 990
M.L. 529
M.L. 991
M.L. 530
M.L. 992
M.L. 993
M.L. 994
M.L. 995
HEMATITE
MASSIVE
CATHEDRAL
(Vertical Pinnacle)
Rocky Gully
Rocky Ck
Indurated Sandstones
FOUNTAIN
Limestones, Slates, Schists and other
Limestones, Slates, Schists
W.H.R. Del.

Other Notes on Minerals and Rocks.

Gold.—Bower Bird Creek on the Leichhardt River Field, 70 miles to the north-west of Cloncurry, was worked for gold many years ago and is referred to in the Report by the late Mr. Rands.[29] Gold has been found in a number of localities about Cloncurry, including Gilded Rose on Bishop's Creek, Soldier's Cap, Pumpkin Gully, Two-mile Creek, Top Camp Diggings, The Last Call, Bell's Camp, and Tip Top Camp on Agate Downs Goldfield. Notes are given on these mines in the report and also in the Six Reports by Dr. R. L. Jack on the Geological Features of the part of the District proposed to be traversed by the Transcontinental Railway.

At the present time there are no gold mines operating on the Cloncurry Fields, and statistical returns also show that in the years 1917 and 1918 there was no gold production. Altogether the field has produced 1,093 oz. of reef gold and 3,098 oz. of alluvial gold, with an additional 122 oz. from the treatment of tailings, making a total of 4,313 oz., the estimated value of which is £17,395.

Silver-Lead-Zinc.—The occurrence of silver-lead-zinc deposits at Lawn Hills has been known for many years past, and several reports have been published, official and otherwise, concerning the prospects of their development. Mr. Cameron examined Lawn Hills in 1900[30] and Mr. Ball in 1911[31], the report by the latter containing a mass of data bearing on the mines, ore deposits, and geological features.

The country to the south-east of the Lawn Hills Mines was cursorily examined, and shows no special variation from that nearer Mount Oxide, or indeed, from that all through the Cloncurry mineral belt, and everything points to the copper and silver-lead deposits being in the same geological series. A lead lode was reported to occur in the Dugald River, but nothing has been heard of it for many years[32].

At the Lady Fanny Mine on the Urandangi road, 23 miles westerly from the Duchess, a silver-copper lode was opened and three shafts sunk on it, the respective depths of which are 37, 31, and 21 feet. Twelve tons of ore were taken out of the lode, of

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[29] Leichhardt Goldfield and Other Mining Centres in the Cloncurry District. W.H.R. Brisb. By Auth. 1895. pp. 7. G.S.Q. Pub. No. 104.

[30] Mr. Cameron. Lawn Hills Report, 1900.

[31] Mr. Ball. Burketown Mineral Field Report, 1911.

[32] Dr. Jack. Six Reports. Page 9.

which six tons yielded at the rate of over 1,300 oz. of silver to the ton, but the lode pinched out in hard schist country and the mine was abandoned.

Native silver occurred in the lode and some pieces of the ore recently received show the presence of Horn silver (the chloride), a silver-bearing limestone, and a silver selenide.*

Manganese.—A lode of manganese dioxide has been discovered two miles north-east of Florence Station on the Cloncurry-Kuradala Railway line. The lode is said to be 25 feet wide with a pronounced outcrop, and can be traced for a quarter of a mile in schist and slate country in the neighbourhood of granite. Samples of the ore, on being tested, showed the presence of 46 per cent. of manganese.

Cobalt.—A discovery of a lode containing a high percentage of cobalt has been made in what is described as a diorite and schist formation about 19 miles south of Selwyn Railway Station (Mount Elliott) and 5¾ miles from Mount Dora. The lode, according to Mr. Reid who has recently visited the locality and who is making a report on the deposit, is traceable for 300 feet, and is about five feet wide, beautiful specimens of Erythrine, the magenta-coloured arsenate of cobalt, showing close to the surface in association with Cobaltite, the whitish metallic arseno-sulphide. The arseno-sulphide, which is very pure, shows on analysis the following composition, while the arsenate, which has not been analysed, contains about 26 per cent. of cobalt:—

Analysis of Cobaltite from near Mount Elliott.

Cobalt	33.1 per cent.	Arsenic	40.2 per cent.
Nickel	Nil.	Sulphur	15.8 „
Iron	2.1 „	Insoluble ..	8.3 „

Chalcotrichite.—Very beautiful specimens of this variety of cuprite, the oxide, are to be seen at the Kalkadoon Mine, Mount Cuthbert. The matrix is a dark reddish gossany ironstone, in the cavities of which the mineral occurs as very beautiful slender red crystals and fibrous bunches, together with minute cubical crystals of cuprite.

Ferric Oxide.—At Mount Oxide the hematite mass referred to on a previous page has a very large exposure on the side of Cave Creek and hundreds of thousands of tons of the mineral of a bright red colour are to be seen in a large cliff section. A

* An analysis of the silver selenide shows the presence of 72.06 per cent. of silver and 25.40 per cent. of selenium, with lead and sulphur absent. Physically it does not agree with the characters of Naumannite and is probably a new mineral. B.D.

sample of the oxide was made up of pieces taken from all over the outcrop, and the analysis of this showed the presence of 99·8 per cent. of ferric oxide.

As a flux or as an iron ore the hematite would have some value, but as a pigment it was thought to have special qualities. Experiments, however, have shown that the red colour is not well developed on grinding, however finely powdered, and when washed settles into two portions made up of a light bright powder and a dark heavy crystalline powder. Being so wonderfully pure it was thought that a good colour could be obtained from it, and the failure to produce this rather goes to show that iron oxides may be very rich in composition but may make very poor pigments. The colour produced by grinding is a dark Indian red, and the subject for experimental research is to find out if artificial means can so brighten the colour as to allow it being used as a pigment.

Mica.—Some years ago a discovery of muscovite mica was made in a granite and schist area at Rifle Creek, about 68 miles westerly from Cloncurry[33]. This deposit has received some attention lately, and the approximate position has been determined to be on the western side of the west branch of the Leichhardt River. The locality can be approached from the Cloncurry-Camooweal road on the north side, but a more convenient route is *viâ* Bushy Park Station, on the Wills River, from which it is situated 50 miles to the N.N.W.

The mica is in large flat sheets, and the surface indications are very favourable, the lodes or beds being very thick, extensive, and regular. The quoted reference contains additional information concerning the deposits and the uses to which the mineral may be applied.

Gypsum.—About the Mulligan River in the salt areas this mineral is of common occurrence, and at the Pulchara Waterhole on this river about latitude 24 degrees there are said to be thousands of tons of the mineral of excellent quality contained in several very thick seams. It also occurs in small quantities about Boulia and at Min Min Creek on Warenda Run to the east of Boulia.

The massive variety of Gypsum is the "copai" burnt and used by the blacks for personal adornment. The clear variety, Selenite, will not slack after burning in the way the blacks conduct the operation, and therefore by them is not called "copai."

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[33] Queensland Mineral Deposits. A Review of occurrences, &c., &c. By B. Dunstan. No. 1 Mica. Q.G.M. Jour., June, 1916, vol. 17, pp. 263-5.

Barytes.—This mineral occurs in small quantities in many localities in association with slates and schists. The white variety of the mineral, so much in demand as a pigment, has been discovered near Quamby, a railway station north of Cloncurry, but is mixed with much that is ironstained.

Ribbonstone.—A finely-banded quartzite occurring in many places around Camooweal and in other localities further west in the Northern Territory has been given this name locally. It is frequently seen as fragments interbedded in a recently formed brecciated limestone, and is, apparently, derived from a much older formation.

The colours are variable, and well-marked specimens show alternating white, grey, and red bands, generally quite regular but sometimes with the markings faulted or contorted. It is now being used for jewellery purposes, particularly for brooches, sleeve links, buttons, and watch-chain pendants, and makes a very effective ornament when mounted in gold.

Staurolite.—The occurrence of this silicate of alumina and lime has been observed near the Wee MacGregor Mine close to the terminus of the Ballara railway line. The mineral occurs *in situ* in a decomposed mica schist in association with garnet, and also loosely in the watercourse leading down from the schist outcrop. The crystals are exceedingly numerous, although perfect specimens are not common.

The colour is very dark brown or black and the lustre somewhat dull, the crystal being invariably twinned and varying from a quarter to three-quarters of an inch in length. The twinning is usually at right angles with the vertical axis and produces a regular cross, the prisms being rhombic in form, unmodified by secondary facets, and terminated by basal planes. A method of mounting the stones is to drill holes through the axes and mount them in sets of five or six, according to the style of cross required. The operation of drilling is delicate but the stones are hard and not inclined to crack, the effect when mounted showing the gold only at the terminations and at the ring where attached to a chain. The stones are also effective when mounted singly and used as brooches.

Laterites.—To the south of Cloncurry about the Selwyn Range where the ? Silurian rocks are to some extent covered by Jurassic freshwater limestones there are formations of laterite partly resting conformably on the limestones and partly on the upturned edges of the older rocks. At Selwyn and Soldiers' Cap, particularly, conspicuous occurrences of the laterites are to

be seen in the form of innumerable isolated tablelands, which dip away to the east to form an unbroken gently sloping plain. No doubt the laterites are portion of the Jurassic outcrop and probably were deposited as volcanic tuffs. Plate 1 shows the position of the isolated tablelands about Selwyn and Soldier's Cap, and Plate 2 illustrates a section at the former locality. Plate 13, fig. 6, is a photo. taken at Selwyn of the tableland country, but the view is not so good as that of some of the tablelands in the same locality.

Limestones.—Six forms of limestone are to be found in the stratified series in or adjacent to the Cloncurry mineral area, their close association with one another frequently causing confusion amongst observers with regard to their age. All are more or less magnesian and some merge into dolomites.

The oldest occurrence is in the Cloncurry Mineral Series, and coarsely crystalline beds of the rock more or less mixed with dolomite may be seen close to the town of Cloncurry interstratified with slates and schists. They are also to be seen in a vast number of outcrops to the south, north, and west.

Another form of limestone is that in which the Cretaceous marine fossils commonly occur on the eastern side of the Cloncurry series, as at Donor's Hill and Kamileroi, on the Cloncurry and Leichhardt Rivers respectively. Some of these limestones are very pure and inclined to be very light in colour, but usually they are sandy and of a bluish or creamy colour.

A third form of deposit is the Jurassic freshwater limestones on the western side and on portions of the eastern side of the Cloncurry Series, in the former case the rocks extending uniformly for hundreds of miles towards and beyond the Northern Territory border. They occur all around Carandotta, Urandangi, Camooweal, and further north, and also about Devonshire and between Selwyn and Boulia to the south. They are in places massive and very impure, but generally thin-bedded and white, and lie over the surface horizontally in the form of large slabs a few inches thick. They do not appear to be fossiliferous on casual observation, but are probably interstratified with sandy beds, in one of which a plant fossil has been discovered.

The fourth form of limestone, of very small extent, is the irregular Post-Tertiary deposits formed on the top of the rocks of the Cloncurry Mineral Belt or on the Jurassic limestones, examples of which are to be seen at Lawn Hills and Riversleigh; the fifth occurrence being that in which irregular deposits are forming at the present time from the denudation of both the old

limestones in the mineral belt and the newer limestones in the Jurassic Series. The sixth form is the occurrence of calcite as lodes in the mineral belt. Such lodes sometimes contain small percentages of copper and are then of some importance as a source of this metal and also as a flux for the copper smelters.

Dolomite and Magnesite.—Dolomite is closely associated with the limestones in the Cloncurry Mineral Belt both as a bedded deposit and as an irregular formation. In the Jurassic limestones the presence of magnesia has been noticed in a large number of localities, and magnesian limestone sometimes merges into normal dolomite and occasionally into magnesite, the carbonate of magnesia.

The old dolomites are generally coarsely crystalline, and if they contain small percentages of copper, which is not unusual, they are used as a copper-bearing flux. The more recent dolomites are usually massive and fine-grained, frequently contain traces of iron, and occasionally form a surface covering to an outcrop of magnesite. Analyses of dolomite samples from the Jurassic limestones at Camooweal and from the Silurian rocks at Mount Cuthbert are given below.

The magnesite is an alteration product of the dolomites and almost always contains lime, although at Mount Cuthbert near the manager's house a sample of pure magnesite was obtained from an outcrop which gave the No. 3 analysis shown in the following table:—

Dolomite and Magnesite Analyses.

	1.	2.	3.
	Per cent.	Per cent.	Per cent.
Moisture and loss	44.4	44.5	49.9
Alumina	0.5	0.8	0.7
Silica	5.2	2.4	0.6
Ferric oxide	0.5	3.7	2.7
Lime	31.2	30.0	1.3
Magnesia	18.1	18.6	44.7
	99.9	100.0	99.9

1, Camooweal. 2 and 3, Mount Cuthbert.

Quartzites.—Three kinds of quartzite occur in the Cloncurry District, all very similar in appearance although very different in their origin and mode of occurrence. First, there are the quartzites existing as lode formations and quite distinct from quartz. These lodes frequently contain copper, and probably result from the alteration of other rock-forming minerals.

Then there is the quartzite produced by the cementation of the old massive sandstones in the Cloncurry Series, which are also mineral bearing and which often form conspicuous surface features in the way of precipitous ranges. The third type is that produced by the superficial cementation of Cretaceous sandstones and the silicification of limestones by hot water solutions from artesian leakages. The second and third forms are much alike and easily mistaken for one another locally, as both are often associated with unaltered limestones, but their geological position is quite distinct.

Chalcedony.—Many places in the Cretaceous and Jurassic limestone areas show occurrences of chalcedony and chert in dolomitic limestone, more particularly near Noranside close to the Burke River on the Cloncurry-Boulia Road. The chalcedony and chert is undoubtedly formed by the replacement of limestone, and probably the change has been brought about by this infiltration of hot artesian water through leakage channels. It is noticeable that these silica deposits are very pronounced in the vicinity of springs or where springs once existed, although, it must be noted, none of the springs are now forming deposits of silica around the vent.

Around Boulia pure white chalcedony is to be seen with the limestone in the rock outcrops, and fossil wood in this locality has also been preserved by infiltration of silica probably derived from an artesian source.

Opal.—At Selwyn the outcrop of what appears to be the extension of the Mount Elliott copper lode has been much altered by ferruginous and siliceous infiltrations. Some mining developments were undertaken by the Mount Elliott Company to prospect for copper on the outcrop of the lode, and the material passed through was found to be made up of ferruginous clay, ironstone, jasper and common opal, with traces of precious opal on some of the joint planes. The common variety of opal has formed very massively in a variety of opaque colours such as red, pink, yellow, and brown, and although very ornamental is of no value. Its presence however shows that in the past the conditions for opalization have prevailed in this locality. The beds of the artesian basin here once covered the Selwyn Range and remnants of rock are to be observed on the tableland about Mount Elliott in the form of lateritic deposits, reference to which has been made on a previous page.

A study of the localities where opal occurs in Western Queensland shows that all are on the borders or within the present limit of the basin of the artesian system, and in consider-

ing the occurrence of the silica deposition in the areas where the springs are flowing, together with the alteration in the sedimentary rocks produced by hot water solutions, it seems very probable that the whole of the opal deposits of Western Queensland have been produced by hot artesian water infiltration in areas of recent or extinct leakages. If this is so then the formation of precious opal will be in progress below the surface at the present time where leakage springs are in active operation.

Deductively, it seems that the presence of flowing springs are indications of recent earth movements, probably originating in the rocks forming the base of the artesian series, and that where deposits of opal and chalcedony have been formed and are now exposed in the surface rocks leakages existed which have become sealed by the silica accumulations.

Fissile Slate.—When passing through the Myally Gorge on the road between Mount Oxide and Dobbin several outcrops of fissile slates were observed. The position is not as definite as desirable as the mileage could not be ascertained, but the outcrops are easily seen in passing along the narrow ravine.

The slates form portions of the Cloncurry Series and are associated with massive outcrops of quartzites and other rocks. Large blocks have tumbled down to the bottom of the gorge from the bed above, which on examination were seen to have a smooth cleavage with faces sometimes over a yard square and with the planes perfectly true. The character of the slate could only be observed on these slightly weathered blocks, and no doubt if a quarry face were opened up the material would show even better effects in cleavages, colour, hardness, toughness, &c.

The locality is very remote from a railway and working it would be out of the question just now, but if a railway to Mount Oxide is established, probably it would be profitable to work the slate as a substitute for the more costly galvanised iron.

Mineral Register.—A register of the minerals occurring in the Cloncurry district is not included in the present report, as one of our Geological Survey Publications contains this information fairly complete up to the year 1908.[34]

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[34] Cloncurry Copper Mining District. Part 1. L. C. Ball. G.S.Q. Pub. 215. 1908.

ANTHONY JAMES CUMMING, Government Printer, Brisbane.

FIG. 1.—MOUNT PHILP: VIEW OF IRONSTONE PEAK, NEAR FOUNTAIN CREEK.

FIG. 2.—MOUNT PHILP: VIEW OF IRONSTONE, NEAR FOUNTAIN CREEK.

FIG. 3.—MOUNT PHILP: LOOKING SOUTH; CATHEDRAL ON THE RIGHT.
(Ironstone continues along the Range in the distance to the left.)

FIG. 4.—MOUNT PHILP: LOOKING SOUTH; CATHEDRAL ROCK.
(The whole of this outcrop is ironstone.)

FIG. 5.—FOUNTAIN RANGE AND GAP: LOOKING WEST FROM MOUNT PHILP.

FIG. 6.—SELWYN TABLETOPS: OUTCROP OF JURASSIC BEDS.